EXCERPTS FROM INFORMATION SUBMITTED BY THE APPELLANTS DURING THE REVIEW PROCESS

- Comments and Reports Submitted by Appellant:
  Dr. Gary Steinberg

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  Dr. Gary Steinberg

DRAFT -- does not represent DEP position

January 10, 2008

To: David Littell, Commissioner

From: Andrew Fisk, Bureau Director, Land & Water Quality

Re: DEP standards on noise and shadow flicker at windpower projects

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Noise standards

The Department has extensive experience with its noise regulations (06-096 CMR, Chapter 375) which are administered under the provisions of the Site Location of Development Act. These rules have been in place since 1979 and have been applied to hundreds of different types of projects around the state. These rules were developed to consider a wide range of activities that generate different types of noise in different settings. The rules were consciously designed to consider many different types of developments, rather than be particular to any one type of noise or development. That said, there are rules and ordinances that have been developed for particular types of projects, including wind power projects.

Following the issuance of the Site Location permit for the Mars Hill windpower project, which required the submission of detailed predevelopment wind studies, the Department worked with the owners of the facility to scope and then review a post-development noise study. This monitoring work began in spring 2007 and is continuing through the winter of 2008. The results of this ongoing assessment of the noise generated by the project have been reviewed by the Department as well as a consultant hired by the Department to peer review the work of the applicant's consultant.

As a result of the consultant's assessment of other existing noise rules developed for windpower projects; the Department's experience with its own noise regulations; and the peer review of both pre- and post-development noise studies at the Mars Hill site, the Department has developed a number of specific conclusions and recommendations regarding the applicability of the noise rules to wind power projects.

Shadow flicker

There has been some comment provided to the Department that wind turbines have caused impacts on private residences from shadow flicker when sun shines behind an operating turbine. Maine's northern latitude may make wind power projects susceptible to causing irritating shadow flicker as a result of low altitude sun during certain times of year. Shadow flicker is described as "moving shadow on the ground resulting in alternating changes in light intensity" and has been noted to cause concern in Northern Europe (NRC 2007). The NRC report notes that there is available modeling software that allows for shadow flicker to be assessed and mitigated in the layout and design of windpower projects that are near developed areas.

DRAFT – does not represent DEP position

Conclusions & recommendations

1. ❖ Except for one clarifying change outlined below, the existing statute and rules are sufficient to allow the Department to regulate the noise effects of wind power turbines. DEP's noise rules conform with the stated best practices of the National Research Council's 2007 report on the "Environmental Impacts of Wind-Energy Projects."
2. ❖ Revise Chapter 375.10 (E) to provide the Commissioner with the authority to "establish any reasonable requirement to ensure that the developer has made adequate provision for the control of noise." Present language limits that authority to the Board of Environmental Protection (BEP) only.
3. ❖ Noise generated from wind turbines does have attributes that warrant particular focus in the review of projects; including the low-frequency modulating noises generated as turbine blades pass by towers.
4. ❖ Analysis of ambient noise generated by wind must be carefully evaluated with specific equipment in pre-development and post-development monitoring so that it is not considered a component of noise generated by a wind turbine.
5. ❖ Post-monitoring studies require careful placement of monitors that account for the effects of topography, prevailing wind (at both ground and turbine levels).
6. ❖ Post-monitoring studies must be conducted during operational conditions that generate the most noise and during seasons or times when sound propagation is likeliest (such as wintertime snow cover).
7. ❖ Variances from the existing noise standards should only be granted in particular circumstances where it is clearly demonstrated that ambient preexisting noise exceeds the noise standards.
8. ❖ LURC should adopt parallel rules to those of the DEP to provide more detailed guidance than LURC rules currently provide and to make standards consistent statewide.
9. ❖ To ensure that shadow flicker is not an adverse impact on protected locations, applicants for windpower projects in either LURC or DEP jurisdiction should demonstrate where shadow falls will occur and to what extent shadow flicker will result. Shadow flicker should be considered in the design of any project and minimized to the extent practicable. There is sufficient statutory authority in DEP and LURC law to request and review this information.

References

National Research Council. 2007. Environmental Impacts of Wind-Energy Projects. (Washington, D.C.: National Academies Press)

We are not Third world!

* 10 Utilize Perception Based Noise Standards

Use DbC

Regulations w/o this are not at current standards or science

[illegible]

Comments by E-Coustics

a. *This is a real stretch of imagination.* In 1979 wind turbines were not a known noise source and thus rules set in 79 should not automatically be accepted as being protective. We now know that wind turbines produce sounds that are not typical of other common community noise sources and as such need different criteria (especially dBC) to provide protection.

b. "As a result of the consultant's assessment of other existing noise rules developed for
windpower projects" From what I know Brown reviewed the noise rules that the wind industry pushed on the mid-west governors. These are the same rules of 50 or 55 dBA and 1000 foot setbacks that the *Wisconsin Task Force was FOIA'd on and then admitted the rules were not based on science but wrtten by lawers from Florida Power and Light.*

1.Except for one clarifying change outlined below, the existing statute and rules are sufficient to allow the Department ....."

This is an assertion based on political pressure not on science. The NRC 2007 report was not reviewed by anyone with acoustical and community noise experience. I found it lacking in any real value as a guide on this issue.

2.Revise Chapter 375.10 (E) to provide the Commissioner with the authority to "establish any reasonable requirement to ensure that the developer has made adequate provision for the control of noise . . ."

Was this change done. I do not have a copy of it is dated "Section 10 Amended: November 21, 1989" If the BEP restriction was lifted I do not know why the date on the version I pulled from their web site is 1989.

3.Noise generated from wind turbines does have attributes that warrant particular focus in the review of projects, including the low-frequency modulating noises generated as turbine blades pass by towers."

Although Fisk is wrong about the cause of the amplitude modulation (The type he describes is from the older style downwind turbines) modern upwind turbines also produce amplitude modulation. *I am assuming he was just confused with nuances here and not trying to be clever.*
But, if its a known problem then how can he dismiss the 5 dB penalty the rules require to be applied without having data for the worst case condition you have experienced to rule it out. *Brown's statement is also not supported. For all practical purposes his conclusion is merely an unfounded assertion.*

4. "Analysis of ambient noise generated by wind must be carefully evaluated with specific equipment in pre-development and post-development monitoring so that...." The hard argument here is that the ambient noise should not only 'not include wind turbine noise' but it should also not include "noise from wind." That means your ambient should be about 20-25 dBA not the high values the study assigned to your properties.

5, 6..Post-monitoring studies must be conducted during operational conditions that generate the most noise and during seasons or times when sound propagation is likeliest (such as wintertime snow cover)."

The studies took the days and conditions as they were. There was no attempt to get the worst case situation and Fisk's comment that Archer was present during one case means that he knows the sounds levels from the turbines can be higher than RSE's studies show. The word "MUST" means something doesn't it?

7."Variances from the existing noise standards should only be granted in particular circumstances where it is clearly demonstrated that ambient preexisting noise exceeds the noise standards."
If this rule was applied to the 5 dB variance granted to UPC/First Wind then lets see the evidence that your ambient "clearly exceeds the noise standards." How can 25 dBA nighttime ambients exceed the 45 dBA standard?

8. Did this happen?

Submitted by Dr. D Stanley

Why ObC must be used. Submitted 2/11/09.

Latest research— The WTS is verified.

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Tuning and sensitivity of the human vestibular system to low-frequency vibration

Neil P. McAngus Todd[a,*], Sally M. Rosengren[b], James G. Colebatch[b]

[a] Faculty of Life Science, Jacksons Mill, University of Manchester, Manchester M60 1QD, UK

[b] Prince of Wales Clinical School and Medical Research Institute, University of New South Wales, Randwick, Sydney, NSW 2031, Australia

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ABSTRACT

Mechanoreceptive hair-cells of the vertebrate inner ear have a remarkable sensitivity to displacement, whether excited by sound, whole-body acceleration or substrate-borne vibration. In response to seismic or substrate-borne vibration, thresholds for vestibular afferent fibre activation have been reported in anamniotes (fish and frogs) in the range −120 to −90 dB re 1 g. In this article, we demonstrate for the first time that the human vestibular system is also extremely sensitive to low-frequency and infrasound vibrations by making use of a new technique for measuring vestibular activation, via the vestibulo-ocular reflex (VOR). We found a highly tuned response to whole-head vibration in the transmastoid plane with a best frequency of about 100 Hz. At the best frequency we obtained VOR responses at intensities of less than −70 dB re 1 g, which was 15 dB lower than the threshold of hearing for bone-conducted sound in humans at this frequency. Given the likely synaptic attenuation of the VOR pathway, human receptor sensitivity is probably an order of magnitude lower, thus approaching the seismic sensitivity of the frog ear. These results extend our knowledge of vibration-sensitivity of vestibular afferents but also are remarkable as they indicate that the seismic sensitivity of the human vestibular system exceeds that of the cochlea for low-frequencies.

The otolith organs, the sacculus, utriculus and lagena, primarily respond to whole-body acceleration or tilt in gravity [9]. In fish these also are important auditory structures for acoustic near-field (particle motion) sensing [13,17]. Several studies have determined behavioral particle motion audiograms for non-specialist species of fish, e.g. the cod, plaice and dab [4]. These have indicated that the region of best sensitivity lies between 40 and 120 Hz, with threshold acceleration values of about −120 dB re 1 g at 80 Hz. During the course of evolution the amniote ear developed new structures for far-field (sound pressure) hearing in air, including the basilar papilla and the mammalian cochlea [6].

It has been established, however, that the otolith organs in terrestrial vertebrates have conserved a particular sensitivity to substrate- or bone-conducted sound [2,15,16,22] consistent with their function as near-field sound sensors in fish [4]. In some species of frog the saccule shows a fish-like band-pass response to acceleration with best frequencies between 20 and 160 Hz and thresholds between −90 and −120 dB re 1 g, while others show a low-pass response with best frequencies at 10–20 Hz [14]. Sensitivity to audio-frequency vibration has also been demonstrated in mammalian vestibular organs. In the monkey [27] best frequencies were between 125 and 177 Hz, with phase-locking threshold as low as −80 dB re 1 g and in the guinea-pig at 500 Hz thresholds were 10 dB above the ABR threshold [3]. At present, however, no such threshold measurements have been obtained for the human vestibular system and this was the aim of our study.

Non-invasive assessment of human vestibular sensitivity can be accomplished by measurement of the powerful vestibulo-ocular reflexes (VOR) to head acceleration. The VOR normally serves to maintain eye gaze with head tilt or rotation and its main effects are mediated by a simple three-neuron arc connecting the vestibular portion of the 8th nerve to the motor neurones of the extraocular muscles [1]. In response to stimuli such as head movements, reflex activity occurs in the extraocular muscles, producing a compensatory eye movement. By placing surface electrodes around the eyes, synchronous muscle activity can be recorded in the form of ocular vestibular evoked myogenic potentials (OVEMPs) [23,25]. These responses are vestibular, rather than cochlear, in origin as they are present in deaf patients but are absent in patients with loss of vestibular function [18,24]. We aimed to measure the tuning and sensitivity of OVEMPs to whole head vibration in the transmastoid plane.

Four volunteers (2 females and 2 males between 31 and 52 years of age) with no auditory or vestibular deficits were stimulated using sinusoidal accelerations between 12.5 and 800 Hz (12.5, 25, 50, 100, 200, 400 and 800 Hz). The subjects were seated

* Corresponding author. Tel.: +44 161 306 5770; fax: +44 161 306 3887.
E-mail address: neil.todd@manchester.ac.uk (N.P.M. Todd).

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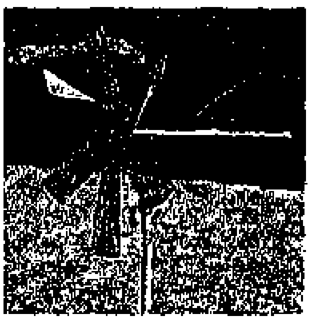

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Simple guidelines for siting wind turbines to prevent health risks[1]

By:

George W. Kamperman, INCE Bd. Cert. Emeritus
Kamperman Associates, Inc.
george@kamperman.com

Richard R. James, INCE
E-Coustic Solutions
rickjames@e-coustic.com

Revision: 1.0

Expedited process is Bad process

Industrial scale wind turbines are a familiar part of the landscape in Europe, U.K. and other parts of the world. In the U.S., however, similar industrial scale wind energy developments are just beginning operation. The presence of industrial wind projects will increase dramatically over the next few years given the push by the Federal and state governments to promote renewable energy sources through tax incentives and other forms of economic and political support. States and local governments in the U.S. are promoting what appear to be lenient rules for how industrial wind farms can be located in communities, which are predominantly rural and often very quiet. Studies already completed and currently in-progress describe significant health effects associated with living in the vicinity of industrial grade wind turbines. This paper reviews sound studies conducted by consultants for governments, the wind turbine owner, or the local residents for a number of sites with known health or annoyance problems. The purpose is to determine if a set of simple guidelines using dBA and dBC sound levels can serve as the 'safe' siting guidelines. Findings of the review and recommendations for sound limits will be presented. A discussion of how the proposed limits would have affected the existing sites where people have demonstrated pathologies apparently related to wind turbine sound will also be presented.

Background

A relatively new source of community noise is spreading rapidly across the rural U.S. countryside. Industrial grade wind turbines, a common sight in many European countries, are now being promoted by Federal and state governments as the way to minimize coal powered electrical energy and its effects on global warming. But, the initial developments using the newer 1.5 to 3 MWatt wind turbines here in the U.S. has also led to numerous

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Bad Science

complaints from residents who find themselves no longer in the quiet rural communities they were living in before the wind turbine developments went on-line. Questions have been raised about whether the current siting guidelines being used in the U.S. are sufficiently protective for the people living closest to the developments. Research being conducted into the health issues using data from established wind turbine developments is beginning to appear that supports the possibility there is a basis for the health concerns. Other research into the computer modeling and other methods used for determining the layout of the industrial wind turbine developments and the distances from residents in the adjacent communities are showing that the output of the models should not be considered accurate enough to be used as the sole basis for making the siting decisions.

The authors have reviewed a number of noise studies conducted in response to community complaints for wind energy systems sited in Europe, Canada, and the U.S. to determine if additional criteria are needed for establishing safe limits for industrial wind turbine sound immissions in rural communities. In several cases, the residents who filed the complaints have been included in studies by medical researchers who are investigating the potential health risks associated with living near industrial grade wind turbines 365 days a year. These studies were also reviewed by the authors to help in identifying what factors need to be considered in setting criteria for 'safe' sound limits at receiving properties. Due to concerns about medical privacy, details of these studies are not discussed in this paper. Current standards used in the U.S. and in most other parts of the world rely on not-to-exceed dBA sound levels, such as 50 dBA, or on not-to-exceed limits based on the pre-construction background sound level plus an adder (e.g. L_{90A}+5 dBA).

Our review covered the community noise studies performed in response to complaints, research on health issues related to wind turbine noise, critiques of noise studies performed by consultants working for the wind developer, and research/technical papers on wind turbine sound immissions and related topics. The papers are listed in Tables 1-4.

Table 1-List of Studies Related to Complaints

Resource Systems Engineering, Sound Level Study - Ambient & Operations Sound Level Monitoring, Maine Department of Environmental Protection Order No. L-21635-26-A-N, June 2007
ESS Group, Inc., Draft Environmental Impact Statement For The Dutch Hill Wind Power Project - Town of Cohocton, NY, November 2006
David M. Hessler, Environmental Sound Survey and Noise Impact Assessment - Noble Wethersfield Wind park - Towns of Wethersfield and Eagle NY For: Noble Environmental Power, LLC January 2007
George Hessler, "Report Number 101006-1, Noise Assessment Jordanville Wind Power Project," October 2006
HGC Engineering, "Environmental Noise Assessment Pubnico Point Wind Farm, Nova Scotia, Natural Resources Canada Contract NRCAN-06-0046," August 23, 2006
John I. Walker, Sound Quality Monitoring, East Point, Prince Edward Island" by Jacques Whitford, Consultants for Prince Edward Island Energy Corporation, May 28, 2007

Table 2- List of Studies related to Health

Nina Pierpont, "Wind Turbine Syndrome – Abstract" from draft article and personal conversations. www.ninapierpont.com
Nina Pierpont, "Letter from Dr. Pierpont to a resident of Ontario, Canada, re: Wind Turbine Syndrome," Autumn 2007
Amanda Harry, "Wind Turbine Noise and Health" (2007)
Barbara J. Frey and Peter J. Hadden, "Noise Radiation from Wind Turbines Installed Near Homes, Effects on Health" (2007)
Eja Pedersen, "Human response to wind turbine noise – Perception, annoyance and moderating factors, Occupational and Environmental Medicine," The Sahlgrenska Academy, Gotenborg 2007
Robin Phipps, "In the Matter of Moturimu Wind Farm Application, Palmerston North, Australia," March 2007
WHO European Centre for Environment and Health, Bonn Office, "Report on the third meeting on night noise guidelines," April 2005

Table 3-List of Studies that review Siting Impact Statements

Richard H. Bolton, "Evaluation of Environmental Noise Analysis for 'Jordanville Wind Power Project,'" December 14, 2006 Rev 3.
Clifford P. Schneider, "Accuracy of Model Predictions and the Effects of Atmospheric Stability on Wind Turbine Noise at the Maple Ridge Wind Power Facility," Lowville, NY – 2007

Table 4-List of Research and Technical papers included in review process

Anthony L. Rogers, James F. Manwell, Sally Wright, "Wind Turbine Acoustic Noise," Renewable Energy Research Laboratory, Dept. of ME and IE, U of Mass, Amherst, amended June 2006
ISO. 1996. Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation. International Organization of Standardization. ISO 9613-2. p. 18.
G.P. van den Berg, "The Sounds of High Winds – the effect of atmospheric stability on wind turbine sound and microphone noise," Ph.D. thesis, 2006
Fritz van den Berg, "Wind Profiles over Complex Terrain," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
William K. G. Palmer, "Uncloaking the Nature of Wind Turbines-Using the Science of Meteorology," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
Soren Vase Legarth, "Auralization and Assessment of Annoyance from Wind Turbines," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
Julian T. and Jane Davis, "Living with aerodynamic modulation, low frequency vibration

Vy important

and sleep deprivation - how wind turbines inappropriately placed can act collectively and destroy rural quietitude," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007	
James D. Barnes, "*A Variety of Wind Turbine Noise Regulations in the United States - 2007,*" Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007	
M. Schwartz and D. Elliott, Wind Shear Characteristics at Central Plains Tall Towers, NREL 2006	
IEC 61400 "Wind turbine generator systems, Part 11: Acoustic noise measurement techniques,".rev:2002	

Discussion

After reviewing the materials in the tables; we have arrived at our current understanding of wind turbine noise and its impact on the host community and its residents. The review showed that some residents living as far as 3 km (two (2) miles) from a wind farm complain of sleep disturbance from the noise. Many residents living one-tenth this distance (300 m. or 1000 feet) from a wind farm are experiencing major sleep disruption and other serious medical problems from nighttime wind turbine noise. The peculiar acoustic characteristics of wind turbine noise immissions cause the sounds heard at the receiving properties to be more annoying and troublesome than the more familiar noise from traffic and industrial factories. Limits used for these other community noise sources do not appear to be appropriate for siting industrial wind turbines. The residents who are annoyed by wind turbine noise complain of the approximately one (1) second repetitive swoosh-boom-swoosh-boom sound of the turbine blades and "low frequency" noise. It is not apparent to these authors whether the complaints that refer to "low frequency" noise are about the audible low frequency part of the swoosh-boom sound, the one hertz amplitude modulation of the swoosh-boom sound, or some combination of both acoustic phenomena.

To assist in understanding the issues at hand, the authors developed the 'conceptual' graph for industrial wind turbine sound shown in Figure 1. This graph shows the data from one of the complaint sites plotted against the sound immission spectra for a modern 2.5 MWatt wind turbine; Young's threshold of perception for the 10% most sensitive population (ISO 0266); and a spectrum obtained for a rural community during a three hour, 20 minute test from 11:45 pm until 3:05 am on a windless June evening in near Ubly, Michigan a quiet rural community located in central Huron County. (Also called: Michigan's Thumb.) It is worth noting that this rural community demonstrates how quiet a rural community can be when located at a distance from industry, highways, and airport related noise emitters.

During our review we posed a number of questions to ourselves related to what we were learning. The questions (italics) and our answers are:

Must be used!

Low f must be addressed

Do National or International or local community Noise Standards for siting wind turbines near dwellings address the low frequency portion of the wind turbine's sound immissions?[2] No! State and Local governments are in the process of establishing wind farm noise limits and/or

[2] Emissions refer to acoustic energy from the 'viewpoint' of the sound emitter, while immissions refer to acoustic energy from the viewpoint of the receiver.

wind turbine setbacks from nearby residents, but the standards incorrectly presume that limits based on dBA levels are sufficient to protect the residents.

Do wind farm developers have noise limit criteria and/or wind turbine setback criteria that apply to nearby residents? Yes! But the Wind Industry recommended residential wind turbine noise levels (typically 50-55 dBA) are too high for the quiet nature of the rural communities and may be unsafe for the nearest residents. An additional concern is that some of the methods for implementing pre-construction computer models may predict sound levels that are too low. These two factors combined can lead to post-construction complaints and health risks.

Too High!

Are all residents living near wind farms equally affected by wind turbine noise? No, children, people with pre-existing medical conditions, especially sleep disorders, and the elderly are generally the most susceptible. Some people are unaffected while some nearby neighbors develop serious health effects caused by exposure to the same wind turbine noise.

How does wind turbine noise impact nearby residents? Initially, the most common problem is chronic sleep deprivation during nighttime. According to the medical research documents, this may develop into far more serious physical and psychological problems

What are the technical options for reducing wind turbine noise immission at residences? There are only two options: 1) increase the distance between source and receiver, and/or 2) reduce the source sound power immission. Either solution is incompatible with the objective of the wind farm developer to maximize the wind power electrical generation within the land available.

A NOT possible For Lincoln or other Lake areas

Lincoln a B.A.D. Candidate because of geography.

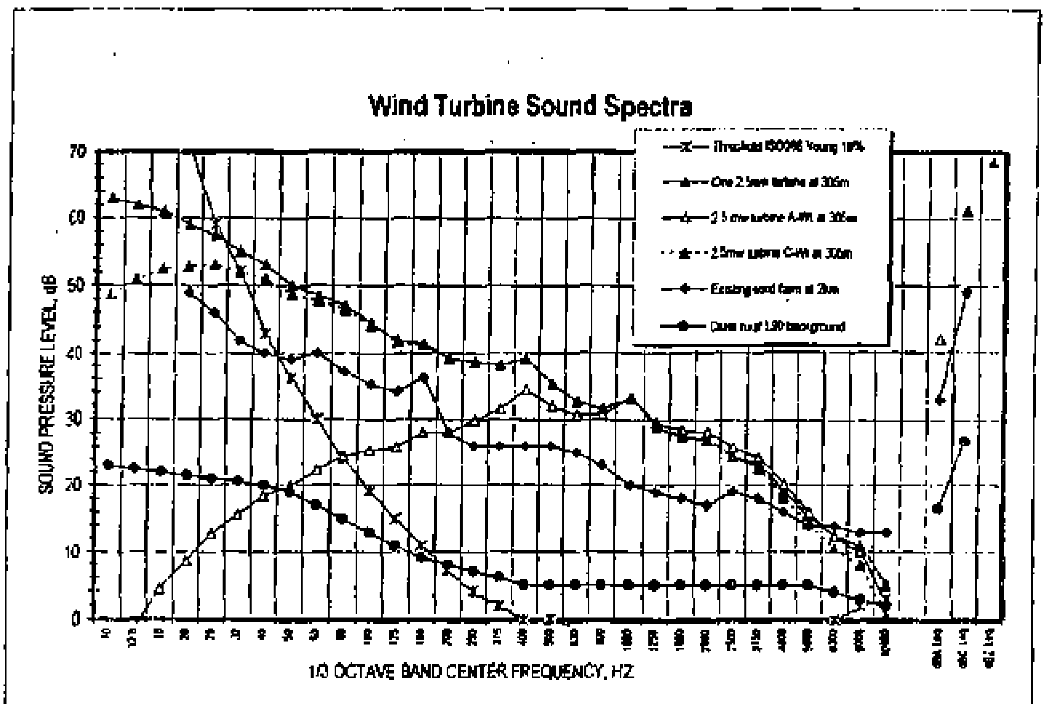


Figure 1-Generalized Sound Spectra vs. perception and rural community L_{90A} background 1/3 octave SPL

Is wind turbine noise at a residence much more annoying than traffic noise? Yes, researchers have found that "Wind turbine noise was perceived by about 85% of the respondents even when the calculated A-weighted SPL were as low as 35.0–37.5 dB. This could be due to the

→ Amplitude Modulated noise Lone with turbines -

presence of amplitude modulation in the noise, making it easy to detect and difficult to mask by ambient noise." [JASA 116(6), December 2004, pgs 3460-3470, "Perception and annoyance due to wind turbine noise-a dose-relationship" Eja Pedersen and Kerstin Persson Waye, Dept of Environmental Medicine, Goteborg University, Sweden]

Why do wind turbine noise immissions of only 35 dBA disturb sleep at night? This issue is now being studied by the medical profession. The affected residents complain of the middle to high frequency swooshing sounds of the rotating turbine blades at a constant repetitive rate of about 1 hertz plus low frequency noise. The amplitude modulation of the swooshing sound changes continuously. The short time interval between the blade's swooshing sounds described by residents as sometimes having a thump or low frequency banging sound that varies in amplitude up to 10 dBA. This may be a result of phase changes between turbine emissions, turbulence, or an operational mode.. The assumptions about wall and window attenuation being 15 dBA or more may not be sufficiently protective considering the relatively high amplitude of the wind turbine's low frequency immission spectra.

Good

Standards are not correct when good science

What are the typical wind farm noise immission criteria or standards? Limits are not consistent and may vary even within a particular country. Example criteria include: Australia-the lower of 35 dBA or L_{90} + 5 dBA, Denmark-40 dBA, France L_{90} + 3 (night) and L_{90} + 5 (day), Germany-40 dBA, Holland-40 dBA, United Kingdom-40 dBA (day) and 43 dBA (night) or L_{90} + 5 dBA, Illinois-55 dBA (day) and 51 dBA (night), Wisconsin-50 dBA and Michigan-55 dBA. Note: Illinois statewide limits are expressed only in nine contiguous octave frequency bands and no mention of A-weighting for the hourly L_{eq} limits. Typically, wind turbine noise just meeting the octave band limits would read 5 dB below the energy sum of the nine octave bands after applying A-weighting. So the Illinois limits are approximately 50 dBA (daytime 7 AM to 10 PM) and 46 dBA at night, assuming a wind farm is a Class C Property Line Noise Source.

for our ordinances here

Testimony speech

What is a reasonable wind farm sound immission limit to protect the health of residences? We are proposing an immission limit of 35 dBA or L_{90A} + 5 dBA whichever is lower and also a C-weighted criteria to address the impacted resident's complaints of wind turbine low frequency noise: For the proposed criteria the dBC sound level at a receiving property shall not exceed L_{90A} + 20dB. In other words, the dBC operating immission limit shall not be more than 20 dB above the measured dBA (L_{90A}) pre-construction nighttime background sound level. A maximum not-to-exceed limit of 50 dBC is also proposed.

Use DbC!

Why should the dBC immission limit not be permitted to be more than 20 dB above the background measured L_{90A}? The World Health Organization and others have determined a sound emitter's noise that results in a difference between the dBC and dBA value greater than 20 dB will be an annoying low frequency issue.

WHO standard needed

Is not L_{90A} the minimum dBA background noise level? This is correct, but it is very important to establish the statistical average background noise environment outside a potentially impacted residence during the quietest (10 pm to 4 am) sleeping hours of the night. This nighttime sleep disturbance has generated the majority of the wind farm noise complaints throughout the world. The basis for a community's wind turbine sound immission limits would be the minimum 10 minute nighttime L_{90A} plus 5 dB for the time period of 10 pm to 7 am. This would become the Nighttime Immission Limits for the proposed wind farm. This can be accomplished with one or several 10 minute measurements during any night when the atmosphere is classified stable with a light wind from the area of the proposed wind farm. The Daytime Limits (7 am to 7 pm) could be set 10 dB above the minimum nighttime L_{90A} measured noise, but the nighttime criteria will always be the limiting sound levels.

A nearby wind farm meeting these noise immission criteria will be clearly audible to the residents occasionally during nighttime and daytime. Compliance with this noise standard would be determined by repeating the initial nighttime minimum nighttime L_{90A} tests and adding the dBC (L_{eqC}) noise measurement with the turbines on and off. If the nighttime background noise level (turbines off) was found to be slightly higher than the measured background prior to the wind farm installation, then the results with the turbines on must be corrected to determine compliance with the pre-turbine established sound limits.

industry BIAS & self-serving use

The common method used for establishing the background sound level at a proposed wind farm used in many of the studies in Table 1 was to use unattended noise monitors to record hundreds of ten (10) minute measurements to obtain a statistically significant sample over varying wind conditions or a period of weeks. The measured results for daytime and nighttime are combined to determine the statically average wind noise as a function of wind velocity measured at a height of ten (10) meters. This provides an enormous amount of data but the results have little relationship to the wind turbine sound immission or turbine noise impact in nearby residents. The purpose of this exhaustive exercise often only demonstrates how much noise is generated by the wind. In some cases it appears that the data is used to 'prove' that the wind noise masks the turbine's sound immissions.

* False conclusions used by Big Wind

The most glaring fault with this argument is shown during the frequent nighttime conditions with a stable atmosphere when the wind turbines generate the maximum electricity and noise while the wind at ground level is calm and the background noise level is low. This is the condition of maximum turbine noise impact on nearby residents. It is the condition which most directly causes chronic sleep disruption. Furthermore, this methodology is usually faulty, as much of the wind noise measured by unattended sound monitors is the wind noise generated at the microphone windscreen resulting in totally erroneous results. (See studies in Table 3, esp. Van den Berg)

Van den Berg study

Are there additional noise data to be recorded for a pre-wind turbine noise survey near selected dwellings? Yes, The measuring sound level meter(s) need to be programmed to include measurement of L_{eqA}, L_{10A}, L_{eq90A} and L_{eqC} plus start time & date for each 10 minute sample. These results will be utilized to help validate the L_{90A} data. For example, on a quiet night one might expect L_{10A} less L_{90A} or L_{eqA} to be less than 10 dB. On a windy night or day the difference may be more than 20 dB. There is a requirement for measurement of the wind velocity near the sound measurement microphone continuously throughout each ten (10) minute recorded noise sample. The ten (10) minute average of the wind speed near the microphone shall not exceed 2 m/s (4.5 mph) and the maximum wind speed for operational tests shall not exceed 4 m/s (9 mph). It is strongly recommended that observed samples be used for these tests.

Is there a need to record weather data during the background noise recording survey? One weather monitor is required at the proposed wind farm on the side nearest the residents. The weather station sensors are at standard ten (10) meter height above ground. It is critical the weather be recorded every ten (10) minutes synchronized with the clocks in the sound level recorders without ambiguity in the start and end time of each ten (10) minute period. The weather station should record wind speed and direction, temperature, humidity and rain.

Why do Canada and some other countries base the permitted wind turbine noise immission limits on the operational wind velocity at the 10m height wind speed instead of a maximum dBA or L_{90} + 5 dBA immission level? First, it appears that the wind turbine industry will take advantage of every opportunity to elevate the maximum permitted noise immission level to reduce the setback distance from the nearby dwellings. Including wind as a masking source in the criteria is one method for elevating the permissible limits. Indeed the background noise level does increase with surface wind speed. When it does occur, it can be argued that the increased wind noise provides some masking of the wind farm turbine noise emission. However, in the middle of the night when the atmosphere is defined as stable (no vertical flow from surface heat radiation) the layers of the lower atmosphere can separate and permit wind velocities at the turbine hubs to be 2 to 2.5 times the wind velocity at the 10m high wind monitor but remain near calm at ground level. The result is the wind turbines can be operating at or close to full capacity while it is very quiet outside the nearby dwellings.

actual scenario

This is the heart of the wind turbine noise problem for residents within 3 km (approx. two miles) of a wind farm. When the turbines are producing the sound from operation it is quietest outside the surrounding homes. The PhD thesis of P.G. van den Berg "The Sounds of High Winds" is very enlightening on this issue. See also the letter by John Harrison in Ontario "On Wind Turbine Guidelines."

What sound monitor measurements would be needed for enforcement of the wind turbine sound ordinance? A similar sound and wind 10 minute series of measurements would be repeated at the pre-wind farm location nearest the resident registering the wind turbine noise complaint, with and without the operation of the wind turbines. An independent acoustics expert should be retained who reports to the County Board or other responsible governing body. This independent acoustics expert shall be responsible for all the acoustic measurements including instrumentation setup, calibration and interpretation of recorded results. An independent acoustical consultant shall also perform all pre-turbine background noise measurements and interpretation of results to establish the Nighttime (and Daytime if applicable) industrial wind turbine sound immission limits. At present the acoustical consultants are retained by, and work directly for, the wind farm developer.

Pseudo Science Data

Snake oil Salesmen! SAM! Potential ...

This presents a serious problem with conflict of interest on the part of the consultant. The wind farm developer would like to show the significant amount of wind noise that is present to mask the sounds of the wind turbine immissions. The wind farm impacted community would like to know that wind turbine noise will be only barely perceptible and then only occasionally during the night or daytime.

Conflict of interest

Is frequency analysis required either during pre-wind farm background survey or for compliance measurements? Normally one-third octave or narrower band analysis would only be required if there is a complaint of tones immission from the wind farm.

Proposed Sound Limits

The simple fact that so many residents complain of low frequency noise from wind turbines is clear evidence that the single A-weighted (dBA) noise descriptor used in most jurisdictions for siting turbines is not adequate. The only other simple audio frequency weighting that is standardized and available on all sound level meters is the C-weighting or dBC. A standard sound level meter set to measure dBA is increasingly less sensitive to low frequency below 500 Hz (one octave above middle-C). The same sound level meter set to

This is not Rocket Science!
Use C weighting for goodness sake.
C. A. [illegible]

measure dBC is equally sensitive to all frequencies above 32 Hz (lowest note on grand piano). It is well known that dBC readings are more predictive of perceptual loudness than dBA readings if low frequency sounds are significant.

We are proposing to use the commonly accepted dBA criteria that is based on the pre-existing background sound levels plus a 5 dB allowance for the wind turbine's immissions (e.g. L_{90A} +5) for the audible sounds from wind turbines. But, to address the lower frequencies that are not considered in A-weighted measurements we are proposing to add limits based on dBC. The Proposed Sound Limits are presented in the text box at the end of this paper.

For the current industrial grade wind turbines in the 1.5 to 3 MWatt range, the addition of the dBC requirement will result in an increased distance between wind turbines and the nearby residents. For the generalized graphs shown in Figure 1, the distances would need to be approximately double the current distance. This will result in setbacks in the range of 1 km or greater for the current generation of wind turbines if they are to be located in rural areas where the L_{90A} background sound levels are 30 dBA or lower. In areas with higher background sound levels, turbines could be located somewhat closer, but still at a distance greater than the 305 m (1000 ft.) or less setbacks commonly seen in U.S. based wind turbine standards set by many states and used for wind turbine developments.

Use DbC - Science Demands It!

Submitted by R. [illegible]

Proposed Wind Turbine Siting Sound Limits

1. Audible Sound Limit

a. No Wind Turbine or group of turbines shall be located so as to cause an exceedance of the pre-construction/operation background sound levels by more than 5 dBA. The background sound levels shall be the L_{90A} sound descriptor measured during a pre-construction noise study during the quietest time of evening or night. All data recording shall be a series of contiguous ten (10) minute measurements. L_{90A} results are valid when L_{10A} results are no more than 15 dBA above L_{90A} for the same time period. Noise sensitive sites are to be selected based on wind development's predicted worst-case sound emissions (in L_{eqA} and L_{eqC}) which are to be provided by the developer.

b. Test sites are to be located along the property line(s) of the receiving non-participating property(s).

c. A 5 dB penalty is applied for tones as defined in IEC 61400-11.

2. Low Frequency Sound Limit

a. The L_{eqC} and L_{90C} sound levels from the wind turbine at the receiving property shall not exceed the lower of either:

1) L_{eqC}-L_{90A} greater than 20 dB outside any occupied structure, or

2) A maximum not-to-exceed sound level of 50 dBC (L_{90C}) from the wind turbines without other ambient sounds for properties located at one mile or more from State Highways or other major roads or 55 dBC (L_{90C}) for properties closer than one mile.

These limits shall be assessed using the same nighttime and wind/weather conditions required in 1.a. Turbine operating sound immissions (L_{eqA} and L_{eqC}) shall represent worst case sound immissions for stable nighttime conditions with low winds at ground level and winds sufficient for full operating capacity at the hub.

3. General Clause

a. Not to exceed 35 dBA within 30 m. (approx. 100 feet) of any occupied structure.

4. Requirements

a. All instruments must meet ANSI or IEC Precision integrating sound level meter performance specifications.

b. Procedures must meet ANSI S12.9 and other applicable ANSI standards.

c. Measurements must be made when ground level winds are 2m/s (4.5 mph) or less. Wind shear in the evening and night often results in low ground level wind speed and nominal operating wind speeds at wind turbine hub heights.

d. IEC 61400-11 procedures are not suitable for enforcement of these requirements except for the presence of tones.

Maddox, Becky

From:	GNS [gernish@yahoo.com]
Sent:	Tuesday, March 24, 2009 6:11 PM
To:	warren_brown@umit.maine.edu; Maddox, Becky
Subject:	Rollins line study data
Attachments:	Rollins South sound contour map.pdf; Rollins North sound contour map.pdf; Rollins North1.pdf; Rollins North.pdf

Rollins South sound contour ma... Rollins North sound contour ma... Rollins North1.pdf (506 KB) Rollins North.pdf (506 KB)

Dear Mr Brown,

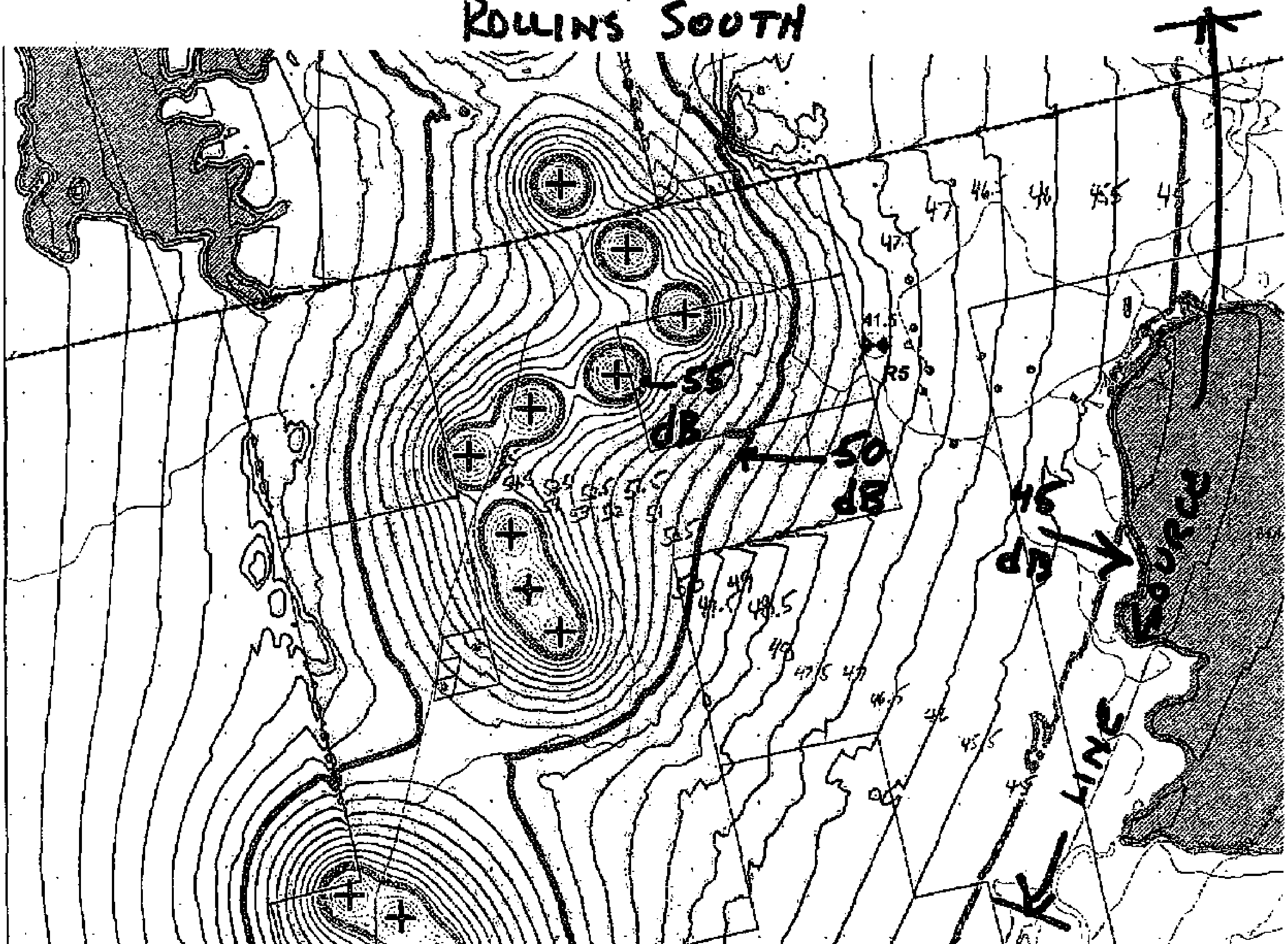
I have been in recent communications with Rick James of E-coustics concerning problems with the point source DBa study for this project. A line source study has not been done. The attached data(line source) will show much more severe noise issues with this project , and many more properties being adversely affected beyond current allowed noise limits. Mr. Rick James is reviewing this data as well, and will forward any modifications that might be found to you. The enclosed studies should be utilized with the understanding that a E-coustic review is also under way shortly. I will be calling you shortly to discuss this as well.

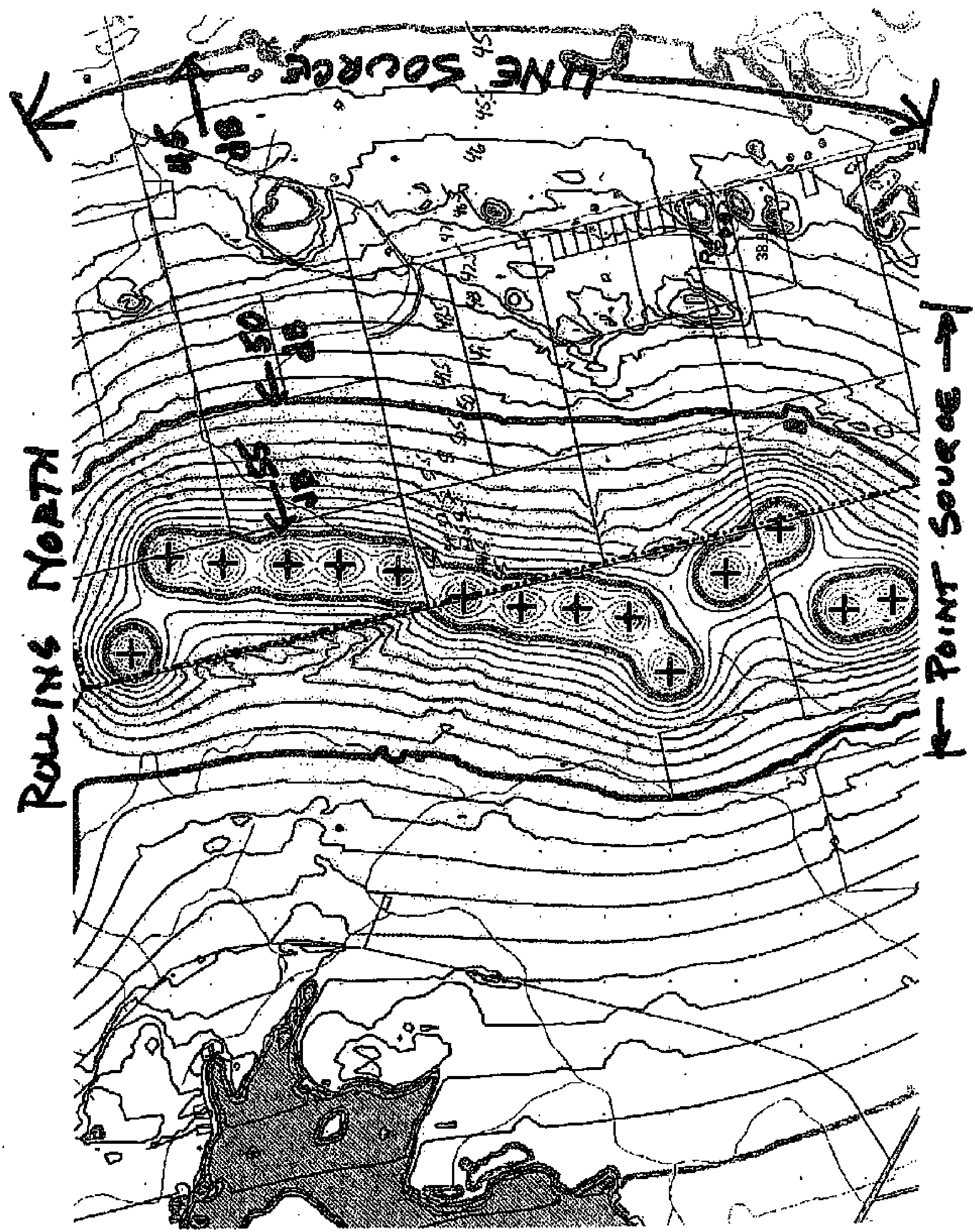
Thank you very much.

Dr. Gary Steinberg
207 794 8174
Lincoln, Me. o4457

This is the end of the mail from GNS...

ROLLINS SOUTH




LINE SOURCE
ROLLING NORTH
POINT SOURCE
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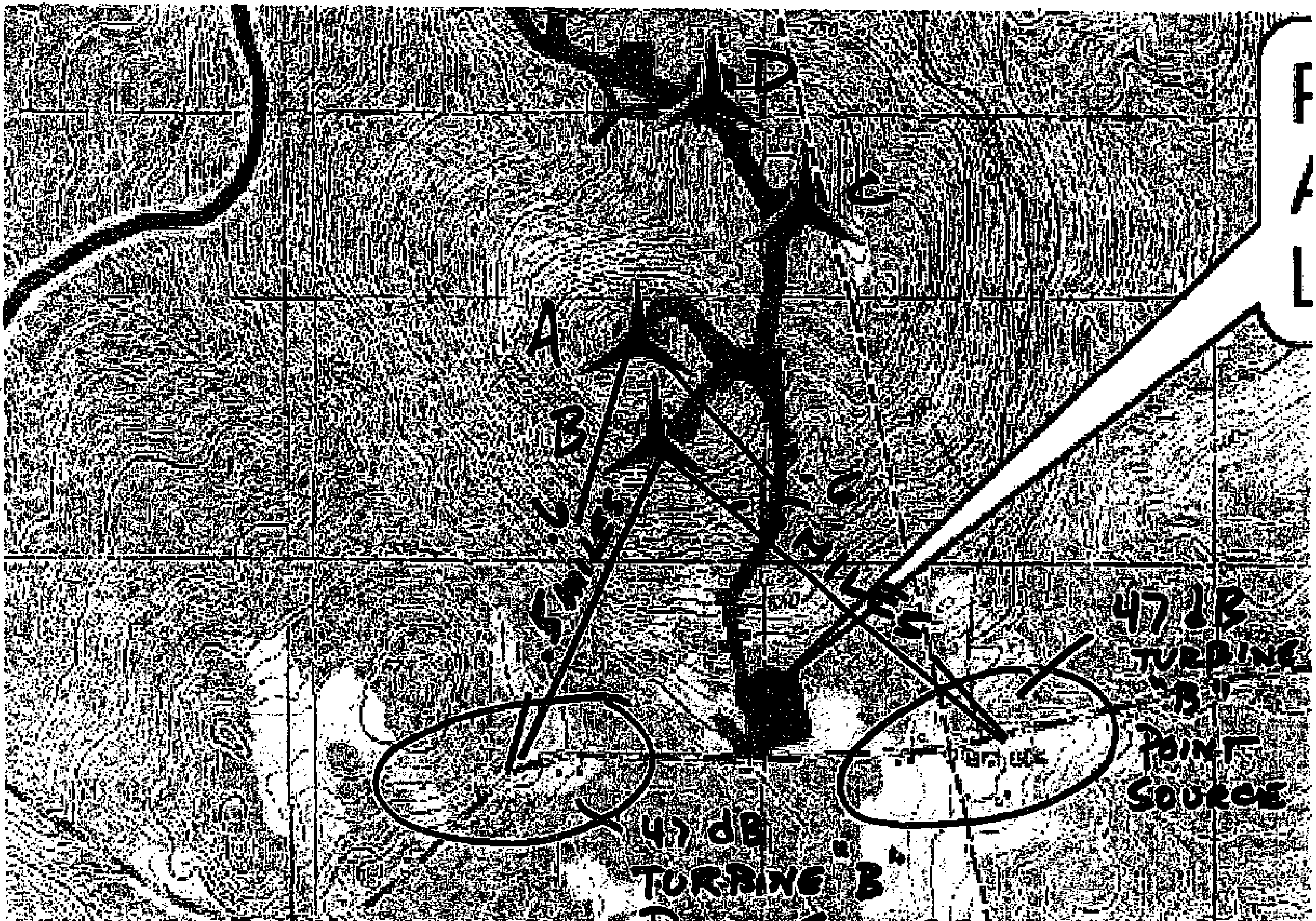
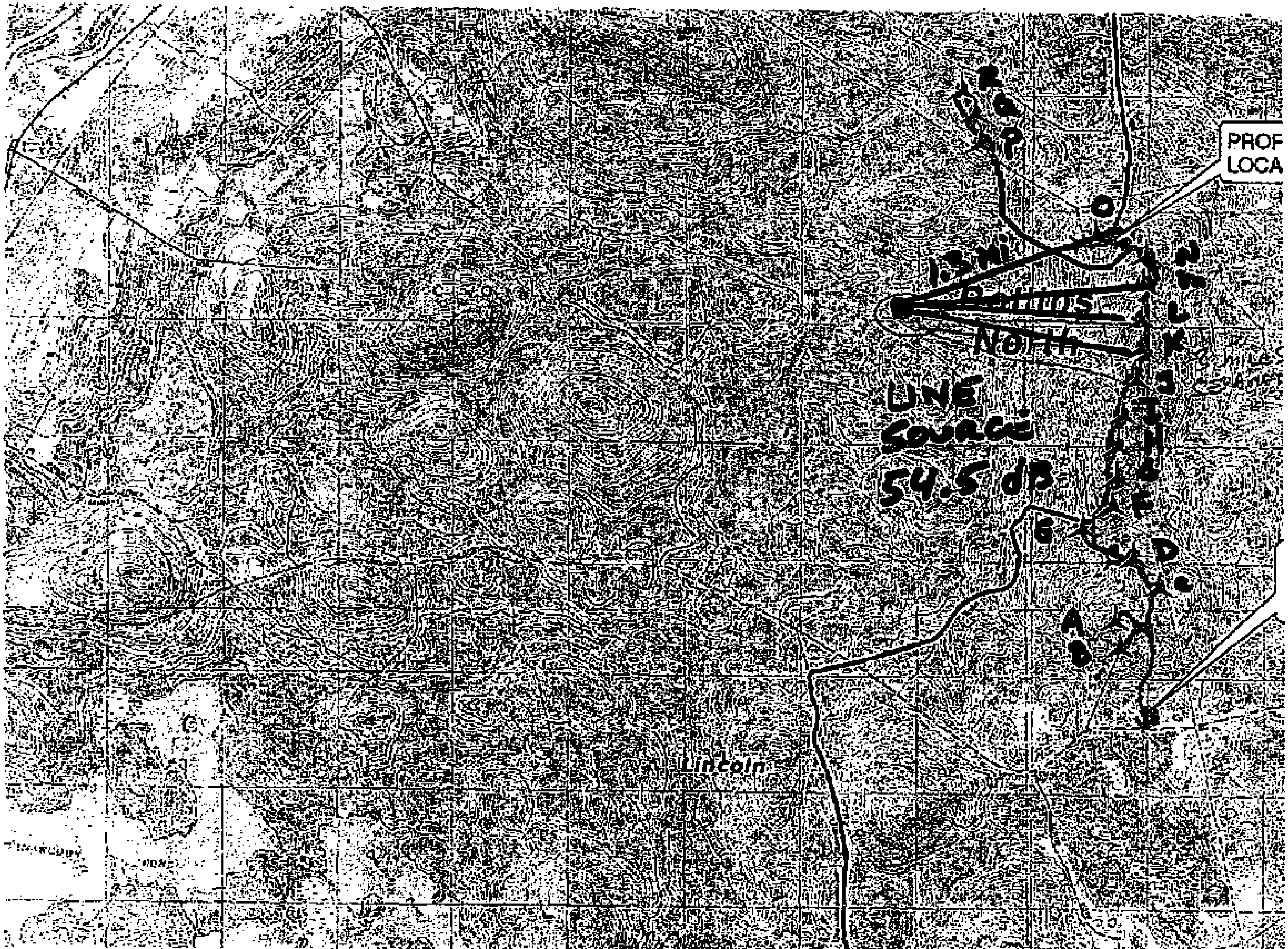
ROLLINS NORTH



ROLLINS NORTH



Rollins North

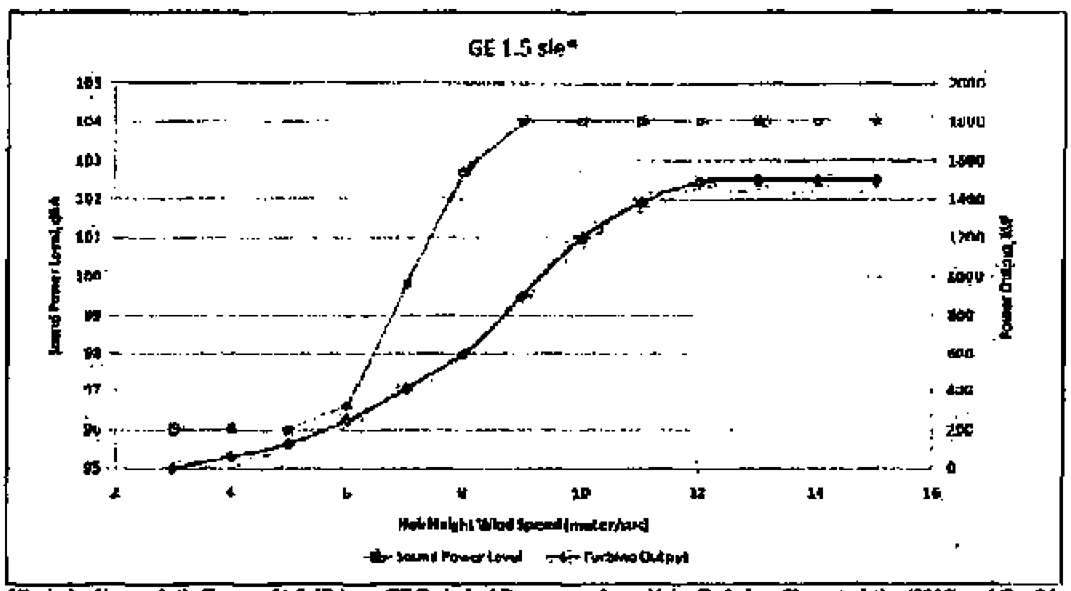
miles	feet	meters	3 dB decrease Line Source GE 1/.5 MW	4.5 db decrease Combined	6 dB decrease Point Source	
0.00	3.28084	1	104	104	104	
0.00	6.56168	2	101	99.5	98	
0.00	13.12336	4	98	95	92	
0.00	26.24672	8	95	90.5	86	
0.01	52.49344	16	92	86	80	
0.02	104.9869	32	89	81.5	74	
0.04	209.9738	64	86	77	68	
0.08	419.9475	128	83	72.5	62	
0.16	839.895	256	80	68	56	
0.32	1679.79	512	77	63.5	50	
0.37	1959.755		76.5	62.75	49	
0.42	2239.72		75	62	48	
0.48	2519.685		75.5	61.25	**47**	house @ .5 miles =47.38 dB
0.53	2799.65		75	60.5	46	point source Turbine B
0.58	3079.615		74.5	59.75	45	
0.64	3359.58	1024	74	59	44	
1.27	6719.16	2048	71	54.5	38	
2.55	13438.32	4096	68	50	32	
5.09	26876.64	8192	65	45.5	26	
10.18	53753.28	16384	62	41	20	
20.36	107506.6	32768	59	36.5	14	
40.72	215013.1	65536	56	32	8	
81.44	430026.2	131072	53	27.5	2	
162.89	860052.5	262144	50	23	-4	
325.78	1720105	524288	47	18.5	-10	
651.55	3440210	1048576	44	14	-16	
1303.11	6880420	2097152	41	9.5	-22	
2606.22	1.38E+07	4194304	38	5	-28	

Operation of the proposed project will consist of 40 wind turbines operating up to 24 hours per day and seven days per week depending on weather conditions.

RSE developed a sound level prediction model to estimate sound levels from operation of the proposed Rollins Wind Project. The acoustic model was developed using the CADNA/A software program to map area terrain in three dimensions, locate proposed wind turbines and calculate outdoor sound propagation from the wind turbines. Area topography and wind turbine locations, for entry into CADNA, were provided to RSE by Stantec based on USGS topographic information and project design.

The wind project will be capable of operating any time of the day or night, including holidays and weekends. However, the wind turbines will only operate when the wind incident on the turbine hub is at or above the cut-in wind speed of 3 meters per second (6.7 mph). During periods of light or calm winds, sound level emissions from the wind project will be virtually non-existent. As the hub-height wind speed increases to 3 meters/sec, the turbines begin to rotate and will reach full sound power output at a wind speed of approximately 9 meters per second (20.1 mph) or 60% of rated power output. Full power generation from the wind turbines occurs when the hub-height wind speed is at or above 11.5 meters per second (25.7 mph). The turbines shutdown or "cut-out" when winds reach 25 meters per second (56 mph). Figure 4 presents a plot of the sound power level and power generation versus wind speed at the turbine hub for wind speeds ranging from 3 to 15 meters per second. Figure 4 indicates that full sound power occurs at or above 9 meters per second and the sound power level is approximately 4 dBA less at a wind speed of 7 meters per second.

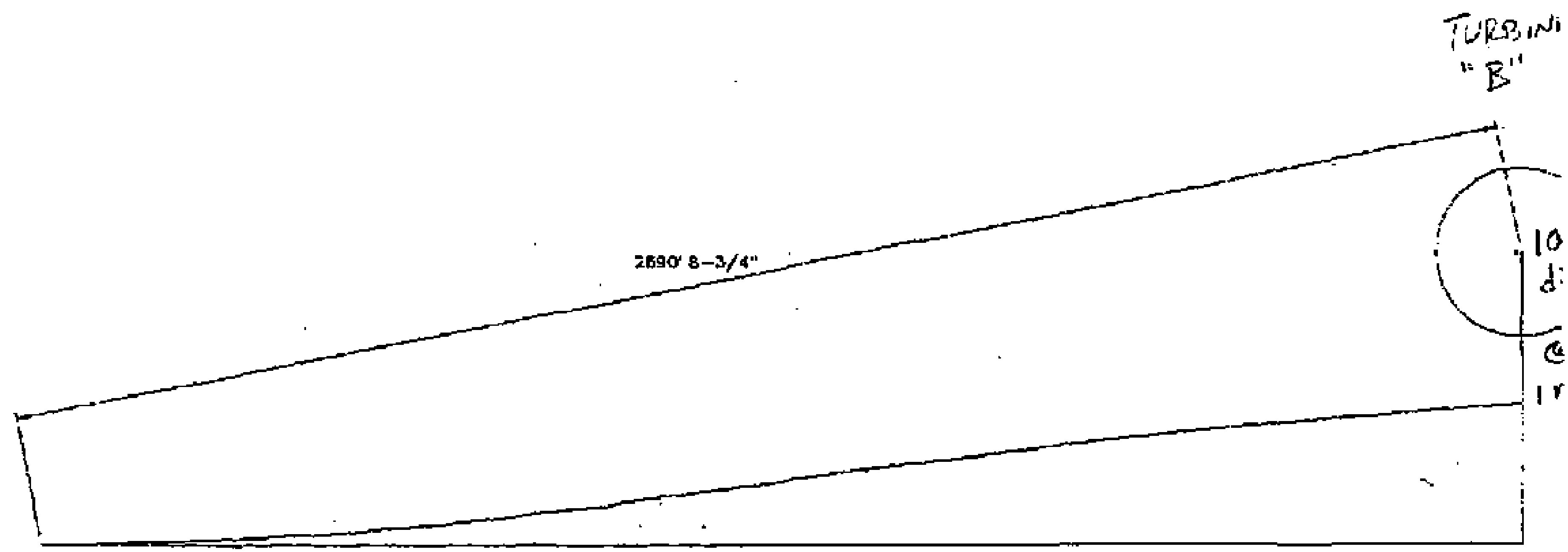
Figure 4. Sound Power Level and Power Output of GE 1.5 sle Wind Turbine in Relation to Hub Wind Speed



SHOULD BE 108 dB

Excludes Uncertainty Factor of ±2 dBA per GE Technical Documentation – Noise Emission Characteristics (2005) and Confidence Level of +2dBA per GE Technical Specification – Noise Emission Compliance. GE Wind Energy, May 2005.

RSE calculated sound levels for simultaneous operation of the GE 1.5 sle wind turbines at all 41 prospective wind turbine locations at full sound power as defined by GE Energy. These moderate to full load conditions exist with wind speeds at or above 9 meters per second (20.1 miles per hour) at the turbine hub. The wind turbines were treated as point sources at the hub height of 80 meters (262 feet) above base/grade elevation using sound power levels from GE Energy (Technical Documentation Wind Turbine Generator System GE 1.5 sl/sle 50 & 60 Hz, Noise Emission Characteristics, 2005). Sound level estimates are based on the operating sound level at full sound power plus an uncertainty factor of



47.38 dB @ 6 dB DECREASE .5 MILES

Submitted 2/11/09

Excerpt

NOISE RADIATION FROM WIND TURBINES INSTALLED NEAR HOMES:
EFFECTS ON HEALTH

With an annotated review of the research and related issues

By Barbara J Frey, BA, MA and Peter J Hadden, BSc, FRICS

Full Report to be submitted via. .pdf via internet.

February 2007
June 2007
www.windturbinenoisehealthhumanrights.com

NOISE RADIATION FROM WIND TURBINES INSTALLED NEAR HOMES: EFFECTS ON HEALTH

With an annotated review of the research and related issues

By Barbara J Frey, BA, MA and Peter J Hadden, BSc, FRICS

Contents

Note: This paper limits its discussion to wind turbines taller than 50m or *from 0.75MW up to 2MW installed capacity.*

Section 1.0 ABSTRACT

Wind turbines are large industrial structures that create obtrusive environmental noise pollution when built too close to dwellings. This annotated review of evidence and research by experts considers the impact of industrial-scale wind turbines suffered by those living nearby. First, the paper includes the comments by some of the families affected by wind turbines, as well as coverage in news media internationally. The experiences described put a human face to the science of acoustics.

Second, the paper reviews research articles within the field of acoustics concerning the acoustic properties of wind turbines and noise. The acoustic characteristics of wind turbines are complex and in combination produce acoustic radiation. Next, the paper reviews the health effects that may result from the acoustic radiation caused by wind turbines, as well as the health effects from noise, because the symptoms parallel one another. Primarily, the consequent health response includes sleep deprivation and the problems that ensue as a result. In addition, this paper reviews articles that report research about the body's response not only to the audible noise, but also to the inaudible components of noise that can adversely affect the body's physiology. Research points to a causal link between unwanted sound and sleep deprivation and stress, i.e., whole body physiologic responses.

These injuries are considered in the context of Human Rights, where it is contended that the environmental noise pollution destroys a person's effective enjoyment of right to respect for home and private life, a violation of Article 8 of the European Court of Human Rights Act. Furthermore, the paper considers the consequent devaluation of a dwelling as a measure of part of the damage that arises when wind turbines are sited too close to a dwelling, causing acoustic radiation and consequent adverse health responses.

The review concludes that a safe buffer zone of at least 2km should exist between family dwellings and industrial wind turbines of up to 2MW installed capacity, with greater separation for a wind turbine greater than 2MW installed capacity.

——Press-Release——Noise——
Noise Complaints On Rise with New Industrial Wind Power Projects

National Wind Watch calls for minimum 1-mile setbacks

Press Release

Contact: Eric Rosenbloom, East Hardwick, Vermont, President
David Roberson, Rowe, Massachusetts, Vice-President

Rowe, Mass., April 2, 2007 -- Noise created by commercial-scale wind turbines has become a major concern around the world as wind power development continues to proliferate. Although the industry claims that modern turbines are quieter -- even as they grow ever larger -- complaints are increasing from people who live near new projects.

While the wind itself may mask some of the noise under some atmospheric conditions, the deep unnatural thumping as the giant blades pass their supporting tower is particularly intrusive. Testimony from hundreds of turbine neighbors confirms this, most recently from Maine, Massachusetts, New York, Pennsylvania, Illinois, Wisconsin, Texas, Canada, the U.K., and New Zealand. Reports can be found at www.wind-watch.org/news and www.wind-watch.org/documents.

The noise is especially intrusive because wind energy facilities are often built in rural areas where the ambient sound level may be quite low, especially at night. On the logarithmic decibel (dB) scale, an increase of 10 dB is perceived as a doubling of the noise level. An increase of 6 dB is considered to be a serious community issue. Since a quiet night in the country is typically around 25 dB, the common claim by wind developers of 45 dB at the nearest home would be perceived as a noise four times louder than normal. And because it is intermittent and directional, those affected assert that one can never get used to it. The disruption of sleep alone presents serious health and human rights issues.

The problem is worse than the industry admits. Frits van den Berg, a physicist at the University of Groningen in The Netherlands, studied noise levels around a German facility of 17 turbines. In a paper published in the November 2004 *Journal of Sound and Vibration,* he found that at night, because the surface air is often more still than the air at the height of the blades, the noise from the turbines is 15 to 18 dB higher than during the day and carries farther. He noted that residents 1.9 kilometers (6,200 feet or 1.2 miles) away expressed strong annoyance with noise from the facility.

The French National Academy of Medicine has called for a halt of all large-scale wind development within 1.5 kilometers of any residence, because the sounds emitted by the blades constitute a permanent risk for people exposed to them. The U.K. Noise Association studied the issue and agreed with the recommendation of a 1-mile setback.

In the U.S., the National Wind Coordinating Committee could not avoid the conclusion that "those affected by noise generated by wind turbines live within a few miles of a large wind power plant or

Section 5
Noise

Submitted comments by 2/11/09

Evergreen conducted a sound level assessment in order to enable as-built compliance with Maine Department of Environmental Protection regulatory requirements for sound as found in 06-096 CMR c. 375.10. Included as Appendix 5-1 is a *Sound Level Assessment* by Resource Systems Engineering. This assessment determines expected sound levels from the project and compares them to the Maine DEP sound level limits for quiet areas of 45 dBA nighttime and 55 dBA daytime at protected locations. Those areas where the sound level limits may be exceeded are part of the project area or, in three other locations, sound easements have been acquired. (see Appendix 5-2).

The report conservatively estimates wind turbine sound levels and propagation by:

-utilizing conservative factors for ground attenuation:
  -specifically mapping the surrounding lakes and ponds as reflective surfaces;
  -excluding potential sound attenuation due to foliage;
-adding 5 dBA to the manufacturer's wind turbine performance specification to account for uncertainty in measurements used to derive turbine sound output; and
-assuming that all turbine are operating simultaneously at continuous full sound output.

The report concludes that the operation of the Rollins Wind Project will not exceed DEP sound level limits at protected locations during construction or routine operation.

EVERGREEN WIND POWER III, LLC
ROLLINS WIND PROJECT
PENOBSCOT COUNTY, MAINE

SOUND LEVEL ASSESSMENT

Prepared by:

Resource Systems Engineering
30 Parkers Way, P.O. Box K
Brunswick, Maine 04011-0835
207 725-7896 / Fax 207 729-6245
E-Mail rse@gwi.net

File 070827

OCTOBER 30, 2008

This paper would fail any peer reviewed empirical review of current acoustic science, readily available to all citizens and communities.
D. G [illegible]

Resource
Systems
Engineering

Appendix 5-1

EVERGREEN WIND POWER III, LLC
ROLLINS WIND PROJECT
PENOBSCOT COUNTY, MAINE
SOUND LEVEL ASSESSMENT

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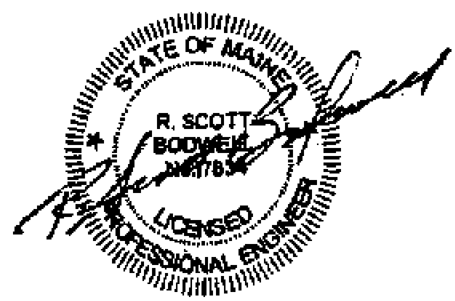
FIGURES

ACKNOWLEDGMENTS

Resource Systems Engineering (RSE) wishes to acknowledge Evergreen Wind Power III, LLC and Stantec for their contributions to this Sound Level Study. RSE personnel responsible for this investigation and report are Charles F. Wallace, Jr., P.E., R. Scott Bodwell, P.E., Tina J. Jones and C. Phillip Botts.



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DISCLAIMER

This document has been prepared in accordance with generally accepted engineering practices associated with environmental acoustics. No other warranty, expressed or implied, is made.

EVERGREEN WIND POWER III, LLC
ROLLINS WIND PROJECT
PENOBSCOT COUNTY, MAINE

Poorly done, non-inclusive or complete, based on industry expedience.

SOUND LEVEL ASSESSMENT

1.0 INTRODUCTION

Resource Systems Engineering (RSE) completed an analysis of sound levels for the Rollins Wind Project, a proposed 60 megawatt (MW) wind energy facility to be located in the Lincoln area of Penobscot County, Maine. The objective of the sound assessment was to determine the expected sound levels from routine operation of the wind project and compare them with relevant environmental noise standards.

Sound levels generated during construction and operation of many types of facilities can be regulated by federal, state, and local noise standards. The Maine Department of Environmental Protection (DEP) regulates noise under authority of the Site Location of Development Law (38 M.R.S.A 481-490). The current Maine DEP noise regulation, Chapter 375.10, Control of Noise, was established in November 1989 to protect certain existing land uses, such as residential properties, schools, and recreation areas, from excessive noise levels generated by new or expanded developments.

The following report provides a description of the wind project, identifies land uses in the project vicinity, presents a summary of Maine DEP noise standards, and sound level estimates for future wind turbine operations. The Sound Level Assessment provides a comprehensive evaluation of sound levels from construction and operation of the wind turbines. Sound levels from construction activity, and operation of the substation and other electric transmission facilities are briefly discussed. The sound level estimates are compared to Maine DEP sound level limits to demonstrate that the Rollins Wind Project will meet applicable sound level limits.

2.0 SOUND AND DECIBELS

Sound is a rapid fluctuation in pressure that the human ear has the potential to detect. The decibel or dB is the unit of measurement for sound. The decibel scale is logarithmic to avoid large unmanageable numbers normally associated with pressure change. Figure 1 shows a comparison of sound pressure and decibel levels for some typical sound environments.

Sound level performance specifications often provide the sound power level emitted by a particular noise source such as a transformer. Similar to sound pressure level, the sound power level or L_w is a logarithmic measure of sound expressed in decibels compared to a specified reference level. The difference is that the reference level for sound power is 10^{-12} watts compared to the reference level for sound pressure which is in units of micropascals.

Undesirable sound is generally referred to as *noise*. The effects of noise depend both on its frequency (or pitch), decibel level, and duration, particularly in relationship to changes in existing sound levels. The frequency of a sound generally refers to the number of vibrations per second, measured in hertz (Hz). The frequencies of sounds audible to humans range from about 20 Hz to 20,000 Hz, with greater sensitivity to frequencies above 1,000 Hz.

Not true – DbC not included, but very important to human biology.

LIST OF ACRONYMS

ANSI	American National Standards Institute
dB	Decibel (Unit of Sound Pressure Level)
dBA	Decibel A-weighted
DEP	Department of Environmental Protection
Hz	Hertz (cycles per second)
ISO	International Organization for Standardization
kVA	KiloVolt-Ampere
L_{A1}	Sound Level Exceeded 1% of a Measurement Period (dBA)
L_{A10}	Sound Level Exceeded 10% of a Measurement Period (dBA)
L_{A50}	Sound Level Exceeded 50% of a Measurement Period (dBA)
L_{A90}	Sound Level Exceeded 90% of a Measurement Period (dBA)
L_{Aeq}	Equivalent Sound Level
$L_{Aeq\text{-}Hr}$	Hourly Equivalent Sound Level
L_w	Sound Power Level
mph	Miles per hour
MRSA	Maine Revised Statutes Annotated
RSE	Resource Systems Engineering

"NO ObC"

Where's C weighted ?

Sound may consist of a single frequency known as a pure tone, but is generally a disorderly mixture of many frequencies. When measuring sound, the A-weighted sound levels are typically used in order to simulate the hearing response of the human ear to varying sound level frequencies. A-weighted sound levels are expressed as dBA.

Sound propagation in air can be compared to ripples on the surface of a pond. The ripples spread out uniformly in all directions of the pond surface decreasing in amplitude as they move further from the source. For every doubling of distance from a stationary hemispherical point source, the sound level drops by 6 dB. Thus if the sound level is 50 dBA at 500 feet, the sound level at 1000 feet will be 44 dBA, and will be 38 dBA at 2000 feet. With an obstacle in the sound path, such as intervening terrain or a building, part of the sound is reflected, part is absorbed and the remainder is transmitted through or around the object. The amount of sound that is reflected, absorbed or transmitted depends on the properties of the object, its size, and the frequency (Hz) of the sound. Properties of an object and its effect on sound propagation are primary considerations in the design of noise control measures.

For constant sounds, a brief measurement close to the source can generally quantify the level of sound over both long and short periods. However, when sound sources vary, longer sampling periods are needed to accurately quantify the sound levels. Integrating sound level meters are commonly used to measure fluctuating sound sources. These meters record the sound level every 1/8 of a second when set to fast response and every one-second on slow response. When set to fast, the instrument measures 480 sound levels every minute and over 28,000 records in an hour. Due to the large number of readings, statistical parameters are used for analysis and comparison of measurement data.

The most commonly used parameter is the equivalent sound level or L_{Aeq}. The L_{Aeq} is used to represent the sound energy during a given sampling period as a constant decibel level. The L_{Aeq} takes all sound level fluctuations into account similar to an averaging technique; however, this is accomplished mathematically to deal with decibels as logarithmic expressions. At a site influenced by variable sounds such as vehicle or aircraft traffic, the L_{Aeq} distributes the traffic sound energy over the entire measurement period to calculate a single decibel level. Short periods of elevated sound levels can significantly increase L_{Aeq} over a measurement period. For example, if the sound level over an hour was 30 dBA except for five minutes when traffic noise measured 60 dBA, the L_{Aeq} for the hour would be 49 dBA.

Other common statistical parameters include L_{A10}, L_{A50} and L_{A90}, which represent the sound level exceeded 10%, 50%, and 90% of the time during the measurement, respectively. The L_{A90} excludes most transient or intermittent noise sources and therefore, is commonly used to determine the value of constant or *background* sound during a measurement. LA50 is the median sound level and can be used to quantify nearly steady operations by removing the contribution of occasional, louder sound events such as wind gusts or traffic.

In order to calculate sound levels resulting from multiple sources, such as wind turbines, it is necessary to combine decibel levels from each source. Decibel levels must be added mathematically to reflect the logarithmic nature of the decibel unit. When two sounds of the same decibel level are combined, the resulting combined sound level is just 3 dB higher than the individual sound levels (e.g. 50 dB + 50 dB = 53 dB). The analysis contained in this report addresses both individual and combined sound sources associated with the proposed wind project.

3.0 SITE DESCRIPTION

The Rollins Wind Project is a 60-megawatt (MW) wind project with approximately 8 miles of associated 115-kilovolt (kV) transmission line to be located in Penobscot County, east and south of Lincoln. A site location map is presented as Figure 2.

The turbine portion of the project consists of 40 General Electric 1.5 megawatt (MW) turbines located in two clusters, Rollins North and Rollins South. Each turbine is 262 feet from the base to the center of the rotor hub, and a total of 389 feet to the tip of a fully extended rotor blade. The project involves permitting 41 potential turbine locations to allow flexibility in final location; only 40 turbines will be constructed. Turbines will be located in the towns of Winn, Lee, Lincoln, and Burlington. The South cluster, located in Lincoln and Burlington, will include 22 of the 23 turbines shown and connect to the northern portion of the project by a 34.5-kV connector line. The North cluster of 18 turbines will be located east of Lincoln center in the towns of Lincoln, Lee and Winn. Power from the 40 turbines will be collected in an overhead 34.5-kV collector line, delivered to the on-site substation, and converted to 115 kV for transmission to a connection point on Line 56 near Mattawamkeag. The substation will be located near the north end of the project (see Figure 2). Relative to applicable sound level limits, operation of the substation and transmission line is not expected to generate significant sound levels. Consequently, sound level estimates for the wind project do not include these facilities.

The majority of the proposed turbine areas are presently used for commercial forestry operations and contain developed logging roads that will be upgraded and used, where appropriate, to minimize clearing and wetland impacts. The turbines will generally run north–south along various ridges with base elevations of the turbines ranging from approximately 700 to 1,260 feet above mean sea level. In addition to the turbine structures, the project will include construction of an operations and maintenance facility at the south end and a substation near the north end of Rollins North.

For the proposed GE wind turbines, spacing between turbines within the two turbine clusters (North and South) will range from a minimum of approximately 720 feet to over 4,000 feet. There are no external ladders or similar structures proposed on the towers and no guy wires or external cables. Access for maintenance will be provided by ladders located inside the towers.

Numerous violations to this.

Based on aerial photography, field surveys and local tax records, uses in the vicinity of the project consist of undeveloped/forestry land in areas surrounding the turbine sites and rural residential properties mostly over 3,000 feet from the proposed wind turbines. The majority of residential properties in the vicinity of the project are located in the Town of Lincoln between the North and South turbine clusters. With the exception of a few seasonal residences (camps) within the general area of Rollins South, the residential properties between Rollins North and South are the nearest to the proposed wind turbines. Additional residential parcels are located in Lee approximately one mile east of Rollins North and in Burlington approximately 4,000 feet east of Rollins South.

Evergreen Wind Power III (Evergreen III) has purchased property or obtained leases with local landowners to install and operate wind turbines at the proposed locations. Evergreen III has also obtained agreements with landowners who may experience sound levels from the project that have the potential to exceed applicable sound level limits. As set forth by Maine DEP 375.10, Section C.5.s, a noise easement exempts the project from Maine DEP noise limits and remains in effect for the specific noise, parcel of land and term covered by the agreement. A Vicinity Site Plan showing the proposed wind turbine layout and substation location in relation to surrounding land uses and residences is shown as Figure 3. Parcels for which Evergreen III has a lease, easement or other agreement are indicated in Figure 3.

old Standards
NOT up to current Science?
where is DbC in DEP 375.10?

4.0 NOISE CONTROL STANDARDS

Relevant noise standards consist of regulations established by the Maine DEP. Maine DEP Regulation Chapter 375.10, *Control of Noise*, established in November 1989, applies hourly sound level limits at facility property boundaries and at nearby *protected locations*. Protected locations are defined as "any location accessible by foot, on a parcel of land containing a residence or approved subdivision...." In addition to residential parcels, protected locations also include but are not limited to schools, state parks, and designated wilderness areas (ref. Maine DEP 375.10.G.16).

The hourly equivalent sound level ($L_{Aeq\text{-}Hr}$) resulting from routine operation of the wind project is limited to 75 dBA at any facility property boundary. The limits at protected locations vary depending on local zoning or surrounding land uses and existing (pre-development) ambient sound levels.

At protected locations within commercially or industrially zoned areas, or where the predominant surrounding land use is non-residential, the hourly sound level limits for routine operation are 70 dBA daytime (7:00 a.m. to 7:00 p.m.) and 60 dBA nighttime (7:00 p.m. to 7:00 a.m.). At protected locations within residentially zoned areas or where the predominant surrounding land use is residential, the hourly sound level limits for routine operation are 60 dBA daytime and 50 dBA nighttime. In addition, where the daytime pre-development ambient hourly sound level at a protected location is equal to or less than 45 dBA and/or the nighttime hourly sound level is equal to or less than 35 dBA, the hourly sound level limits for routine operation are 55 dBA daytime and 45 dBA nighttime. For areas where pre-development ambient sound levels exceed the specified limits at a protected location, limits may be chosen as 5 dBA less than the pre-development sound levels (ref. Maine DEP 375.10.C.1).

In all cases, nighttime limits at a protected location apply up to 500 feet from sleeping quarters. At distances over 500 feet or where no sleeping quarters exist, daytime limits apply during all facility operating hours (ref. Maine DEP 375.10.G.16). Where various limits apply depending on the distance from sleeping quarters, all limits must be met at the protected location.

The Maine DEP regulation establishes sound level limits for construction, maintenance, and tonal and short duration repetitive sounds as follows:

> *Construction* - Sound from nighttime construction is subject to the same nighttime limits as routine operation. Even though daytime construction limits are contained in Maine DEP Chapter 375.10, normal daytime construction sound levels are exempt from this regulation by Maine Statute (38 M.R.S.A. Section 484). Equipment used in construction must also comply with applicable federal noise regulations and must include environmental noise control devices in proper working condition as originally provided by its manufacturer (ref. Maine DEP 375.10.C.2).
>
> *Maintenance* -- Sound from routine, ongoing maintenance activities are considered part of routine operations and subject to the daytime and nighttime limits for routine operation. Sound from occasional, major overhaul activities is regulated as construction activity (ref. Maine DEP 375.10.C.3).
>
> *Short Duration Repetitive and Tonal Sounds* - When routine operations produce a short duration repetitive or tonal sound, 5 dBA is added to the observed sound levels of these sounds for determining compliance. There is also a maximum sound level (L_{Amax}) limit for certain types of short duration repetitive sounds (ref. Maine DEP 375.10.C.1.d and e).

Sounds associated with certain activities are exempt from regulation under Maine DEP Chapter 375.10. Exempt activities associated with the proposed wind project may include (ref. Maine DEP 375.10.C.5):

- Construction activity during daylight or daytime hours, whichever is longer;

- Emergency maintenance and repairs.

An exemption also applies at protected locations where the landowner has conveyed a noise easement to the project that allows the project to potentially exceed the Maine DEP sound level limits.

Local Standard * in development

When a development is located in a municipality that has duly enacted a quantifiable noise standard that (1) contains limits that are not higher than the Maine DEP limits by more than 5 dBA, and (2) limits or addresses the types of sounds regulated by the Maine DEP, then the Maine DEP is to apply the local standard rather than the Maine DEP standard. Further, when noise produced by a facility is received in another municipality, the quantifiable noise standards of the other municipality must be taken into consideration (ref. Maine DEP 375.10.B.1).

Inquiries to town offices and review of land use ordinances for Burlington, Lee, Lincoln and Winn indicate that no quantitative noise standards have been enacted in any of these municipalities.

5.0 EXISTING SOUND LEVELS

No / Not Done must be (will be) ordinance

Measurements of the pre-development ambient sound levels are required only when the developer elects to establish that the daytime and nighttime ambient hourly sound level at representative protected locations exceed 45 dBA and 35 dBA, respectively (ref. Maine DEP 375.10.H.3.1). Without such ambient measurements, the Maine DEP quiet limits of 55 dBA daytime and 45 dBA nighttime apply at nearby protected locations. In recognition of the rural nature of the site and to be conservative, Evergreen III has elected to apply quiet limits at nearby protected locations even though pre-development ambient sound levels under weather conditions suitable for wind turbine operation can exceed the quiet area thresholds of 45 dBA daytime and 35 dBA nighttime.

6.0 SOUND LEVEL LIMITS

Maine DEP sound level limits at protected locations and property lines have been determined for the Rollins Wind Project based on landowner agreements and land uses. Evergreen III has obtained leases or agreements with many local landowners that exempt the project from sound level limits under the Maine DEP noise regulation. As set forth in Maine DEP Chapter 375.10, these sound level limits apply to routine operation of the proposed wind project and substation.

The most restrictive Maine DEP sound level limit of 45 dBA applies during nighttime hours at locations on residential parcels that are within 500 feet of a residence. The quiet daytime limit of 55 dBA applies during daytime hours (7 am to 7 pm) and during all hours at locations on residential parcels that are over 500 from a residence. Maine DEP sound level limits do not apply at protected locations where landowners have signed agreements with Evergreen III authorizing sound from the project that would exceed otherwise applicable Maine DEP sound level limits. Table 1 presents a list of receiver points in the vicinity of the wind project where the most restrictive sound level limits apply. These receiver points are also shown on Figure 3.

Table 1					
Maine DEP Hourly Sound Level Limits (dBA)					
Receiver Point[A]	Description	Distance From Nearest Wind Turbine (ft)	Maine DEP Hourly Limit (dBA) Daytime	Nighttime	Limit Basis
R1	East of Rollins North and 500 feet from dwelling	4,660	55	45	Quiet limits at protected location
R2	Southeast of Rollins North at residential lot line	2,025	55	45	Quiet limits at protected location
R3	Southwest of Rollins North and 500 feet from dwelling	2,140	55	45	Quiet limits at protected location
R4	North of Rollins South at residential lot line along Arab Road	3,090	55	45	Quiet limits at protected location
R5	East of Rollins South and 500 feet from dwelling	2,870	55	45	Quiet limits at protected location

[A]See Figure 3, Vicinity Site Plan.

The Maine DEP regulation specifies sound level limits in terms of hourly A-weighted equivalent sound levels ($L_{Aeq\text{-}Hr}$). At protected locations where tonal or short duration repetitive sound levels are present from operation of the wind project, 5 dBA is added to these sounds for purposes of determining compliance with applicable sound level limits.

7.0 FUTURE SOUND LEVELS

7.1 Construction

Sound from construction activity is both temporary and variable. Many construction machines operate intermittently and equipment varies with each construction phase. A variety of construction equipment will be used to build the wind project including earth-moving equipment for land clearing, excavation, and site grading, and cranes to erect the wind turbines. Typical earth moving equipment and cranes generate sound levels of 75 to 88 dBA at a distance of 50 feet.

Sound levels from construction may be noticeable in the vicinity of the site, especially during blasting, excavation and grading. Local traffic during construction is expected to increase on some public roads along with associated sound levels from construction vehicles. Because of the temporary nature of construction, no adverse or long-term effects are anticipated.

The mobile nature of construction equipment and the manner in which construction work must be done makes complete control of construction sound infeasible. With the possible exception of nighttime blade lifts, construction activity will occur between the hours of 7 a.m. and 7 p.m. or daylight hours, and therefore is not subject to Maine DEP sound limits. Sound from nighttime crane lifts is not expected to exceed sound levels from routine operation.

Other measures to mitigate construction sound levels will include compliance with federal regulations limiting sound from trucks and portable compressors, and ensuring that equipment and sound muffling devices provided by the manufacturer (or equivalent) are kept in good working condition.

7.2 Proposed Operation

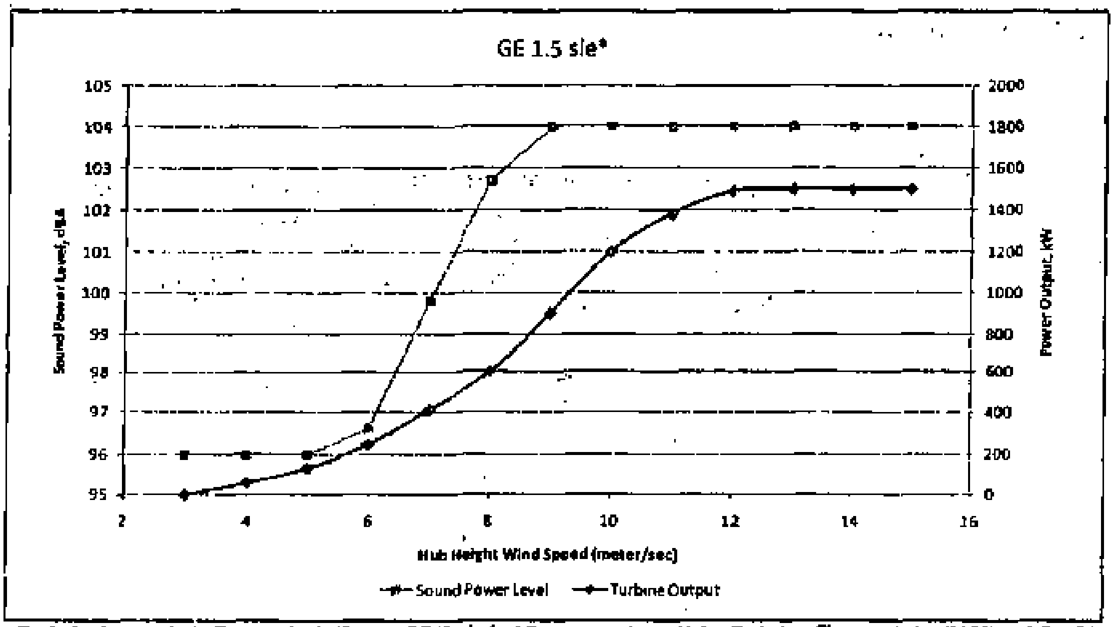
.. NO actual ambient noise level was studied
DbA of 18-23 db in this area is more predictive.

Operation of the proposed project will consist of 40 wind turbines operating up to 24 hours per day and seven days per week depending on weather conditions.

RSE developed a sound level prediction model to estimate sound levels from operation of the proposed Rollins Wind Project. The acoustic model was developed using the CADNA/A software program to map area terrain in three dimensions, locate proposed wind turbines and calculate outdoor sound propagation from the wind turbines. Area topography and wind turbine locations, for entry into CADNA, were provided to RSE by Stantec based on USGS topographic information and project design.

The wind project will be capable of operating any time of the day or night, including holidays and weekends. However, the wind turbines will only operate when the wind incident on the turbine hub is at or above the cut-in wind speed of 3 meters per second (6.7 mph). During periods of light or calm winds, sound level emissions from the wind project will be virtually non-existent. As the hub-height wind speed increases to 3 meters/sec, the turbines begin to rotate and will reach full sound power output at a wind speed of approximately 9 meters per second (20.1 mph) or 60% of rated power output. Full power generation from the wind turbines occurs when the hub-height wind speed is at or above 11.5 meters per second (25.7 mph). The turbines shutdown or "cut-out" when winds reach 25 meters per second (56 mph). Figure 4 presents a plot of the sound power level and power generation versus wind speed at the turbine hub for wind speeds ranging from 3 to 15 meters per second. Figure 4 indicates that full sound power occurs at or above 9 meters per second and the sound power level is approximately 4 dBA less at a wind speed of 7 meters per second.

Figure 4. Sound Power Level and Power Output of GE 1.5 sle Wind Turbine in Relation to Hub Wind Speed



Excludes Uncertainty Factor of ± 2 dBA per GE Technical Documentation – Noise Emission Characteristics (2005) and Confidence Level of +2dBA per GE Technical Specification – Noise Emission Compliance, GE Wind Energy, May 2005.

RSE calculated sound levels for simultaneous operation of the GE 1.5 sle wind turbines at all 41 prospective wind turbine locations at full sound power as defined by GE Energy. These moderate to full load conditions exist with wind speeds at or above 9 meters per second (20.1 miles per hour) at the turbine hub. The wind turbines were treated as point sources at the hub height of 80 meters (262 feet) above base/grade elevation using sound power levels from GE Energy (Technical Documentation Wind Turbine Generator System GE 1.5 sl/sle 50 & 60 Hz, Noise Emission Characteristics, 2005). Sound level estimates are based on the operating sound level at full sound power plus an uncertainty factor of plus 2 dBA based on the GE specification and measurements by RSE of similar turbines during full operation. Sound levels from the wind turbines are not expected to increase at wind speeds greater than 9 meters/sec.

GE Energy determined turbine sound power levels in accordance with IEC 61400-11, Wind Turbine Generator Systems – Part 11: Acoustic Noise Measurement Techniques, 2002. Table 2 provides sound power levels by third octave and whole octave frequency as provided by GE Energy.

← No DDC

TABLE 2

WIND TURBINE SOUND POWER LEVELS
(Wind Speed > 9.0 m/s at turbine hub)

3rd Octave Band Center Frequency, Hz	Sound Power Level, dBA	Octave Band Center Frequency, Hz	Sound Power Level, dBA
50	76.2		
63	79.9	63	85.1
80	82.6		
100	84.8		
125	86.7	125	94.0
160	92.4		
200	90.7		
250	92	250	97.2
315	94		
400	94.3		
500	93.8	500	98.6
630	93.2		
800	94		
1000	92.8	1000	97.9
1250	92.3		
1600	91.5		
2000	89.6	2000	94.5
2500	87.1		
3150	84.8		
4000	82.2	4000	87.3
5000	78.6		
6300	75.9		
8000	71.3	8000	78.1
10000	70.8		
SUM	104	**SUM**	104

Source: Technical Documentation Wind Turbine Generator System GE 1.5sl/sle 50 & 60 Hz, Noise Emission Characteristics, 2005

Sound levels from wind turbine operation were calculated for six receiver points (R1 to R6) in the vicinity of the proposed wind project. Receiver points represent nearby protected locations where the most stringent MDEP nighttime limits apply. Sound levels at these receiver points have the greatest potential to exceed applicable Maine DEP limits. Dwellings and protected locations closer to the wind turbines than the receiver points (see Figures 3 and 6) have entered into a lease or agreement with Evergreen III so that Maine DEP sound level limits do not apply at these properties (ref. Maine DEP 375.10, Section C.5.s). Sound level attenuation from the wind turbines to the receiver points was calculated by the acoustic model in accordance with ISO 9613-2 "Attenuation of sound during propagation outdoors". ISO 9613-2 is an international standard commonly used for predicting sound levels from a noise source for moderate downwind condition in all directions.

For Rollins Wind the prediction model calculates attenuation due to distance, atmospheric absorption and intervening terrain. Conservative factors were applied for ground absorption assuming a mix of hard and soft ground. The surfaces of nearby lakes were specifically mapped and assigned no ground

↑ pseudo, unknown model — no allowance for actual terrain conditions.

absorption as appropriate for a hard, reflective surface. The model calculations exclude attenuation from foliage, which has the potential to reduce sound levels.

The stated accuracy of sound level attenuation calculations per ISO 9613-2 is plus or minus 3 dBA. To compensate for accuracy inherent in the calculation and measurement methods, 3 dBA has been added to the specified sound power levels. This is in addition to the plus 2 dBA uncertainty factor from the GE specification. Consequently, the overall adjustment to the rated sound power levels from GE specifications (Table 2) is plus 5 dBA yielding a sound power level of 109 dBA for model calculations. This adjustment reflects the range of sound levels for the proposed wind project based on RSE sound level measurements of similar operating wind turbines under a variety of weather and site conditions.

inaccurate assumptions

Using the model, sound level contours for operation of the proposed wind project were calculated for the entire study area. These results are presented in Figure 5 with the sound level contours of 55 dBA and 45 dBA are highlighted corresponding to Maine DEP quiet daytime and nighttime limits. Information for the project study area as presented on Figure 5 includes the turbine locations, USGS topographic contours, parcel mapping with hatching to shows parcels with easements or agreements, dwelling locations, public and private roads (red lines), and water bodies. A legend indicating the map symbols is provided on Figure 5.

From these contours, the expected sound level from full operation of the wind turbines can be determined for any point within the study area. Calculated sound levels at the receiver points are indicated on these figures. Table 3 compares estimated sound levels at the receiver points with Maine DEP nighttime sound level limits.

No DbC

No predictive studies done

TABLE 3

ESTIMATED SOUND LEVELS FROM WIND TURBINE OPERATION

Receiver Position	Distance to Nearest Wind Turbine, Feet	Estimated Hourly Sound Level, $L_{Aeq\text{-}Hr}$	Maine DEP Nighttime Limit, dBA
R1	4,660	38	45
R2	2,025	44	45
R3	2,140	43	45
R4	3,090	39	45
R5	2,870	42	45

The results from Table 3 indicate that sound levels at full operation of the wind project will be below the Maine DEP nighttime noise limits at the receiver points.

There are likely to be large fluctuations in wind speed from the hub height of the wind turbines at 262 feet to the regulated height of four to five feet above ground level. This can be a significant factor in sound emissions and outdoor propagation from both the wind project and ambient, non-turbine sound levels. The quietest periods of the day or night generally occur when the winds are light or calm. In addition, as the wind speed incident on a wind turbine drops below 9 meters/sec, sound levels from the turbine are reduced. Ambient, non-turbine sound levels, particularly from wind forces acting on trees and vegetation, may increase significantly when the turbine wind speed reaches 9 meters/sec or greater, as required for full sound power.

Variations in wind speed with elevation (wind gradient) may result in very different wind speeds near the ground than at turbine/rotor heights. In addition, there may be areas near the ground that are shielded from winds at certain directions. For example, with the general ridge line direction running north-south, lower land to the east would be protected from a westerly wind. Under these conditions, high winds may be present near the top and to the west of the wind turbines, but winds may be relatively

Calm night, low altitude studies have not been done. See Van den Berg and other E-coustic analysis!

calm just east of the ridgeline. Consequently, the degree of masking by wind-induced ambient sound will fluctuate depending on the wind speed, direction, and location.

High DbL

A regulated tonal sound occurs when the sound level in a one-third octave band exceeds the arithmetic average of the sound levels in the two adjacent one-third octave bands by a specified dB amount based on octave center frequencies (ref. Maine DEP 375.10.G.24). Turbine performance specifications indicate some potential for tonal sounds to occur in the 160 Hz third-octave band. Both the specifications and measurements of operating turbines by RSE indicate that the tonal threshold of 8 dBA is not likely to be exceeded. Therefore, the wind turbines are not expected to generate regulated tonal sounds. - They produce amplitude modulated sounds as per GE 1.5 mw specifications.

Short duration repetitive (SDR) sounds are a sequence of sound events each clearly discernible that causes an increase of 6 dBA or more in the sound level observed before and after the event. SDR sound events are typically less than 10 seconds in duration and occur more than once within an hour. Measurements and observations by RSE during wind turbine operations indicate that sound levels can fluctuate over brief periods as noted by the passage of wind turbine blades. Observed measurements further indicate that these sound level fluctuations typically range from 2 to 4 dBA and thus do not result in the 6 dBA increase required to be SDR sounds as set forth in Maine DEP 375.10.

Invalid conclusions

8.0 CONCLUSIONS AND RECOMMENDATIONS

The primary objectives of the Sound Level Assessment were to determine applicable sound level limits at protected locations and lot lines, estimate future sound levels from the proposed wind power project, and evaluate compliance with applicable sound level limits. Existing land uses were identified using a combination of site maps, aerial images, and field observations. Sound level estimates of future wind operation were calculated using a terrain-based acoustic model. No DbC, no studies exist for terrain adjustment and attenuation characteristics in Rollins project!

Sound level limits were applied per Maine DEP 375.10 based on land use mapping and landowner agreements. To be conservative with this sound level assessment, quiet limits of 45 dBA nighttime and 55 dBA daytime were utilized per Maine DEP regulations even though pre-development sound levels during conditions suitable for wind turbine operation can exceed Maine DEP thresholds for existing sound levels in a quiet area.

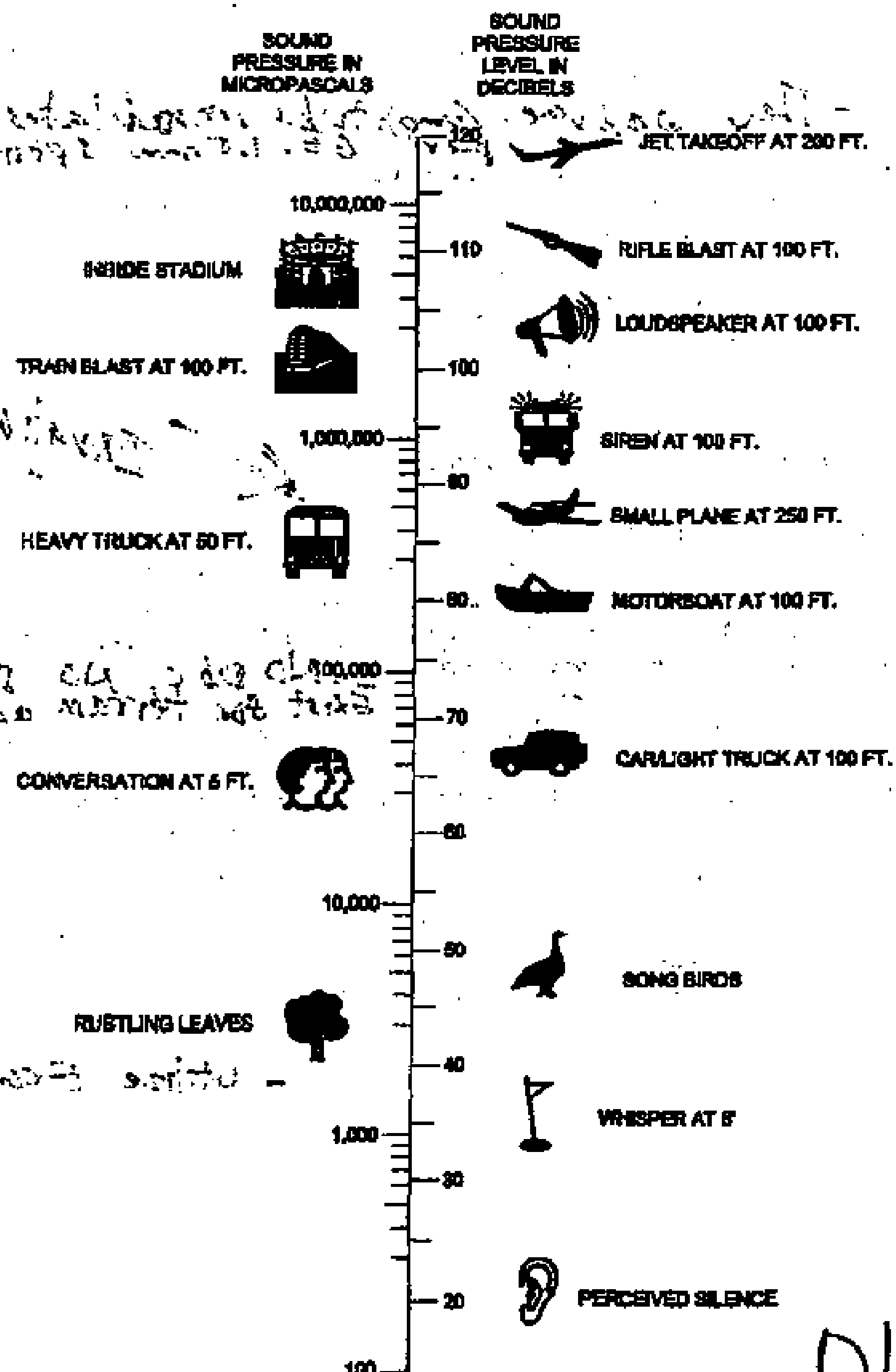
The results of this assessment indicate that sound levels from operation of the Rollins Wind Project will not exceed Maine DEP sound levels limits during construction or routine operation. Specifically, model estimates show that sound levels from the wind project will be below the Maine DEP nighttime limit of 45 dBA within 500 feet of a residence at nearby protected locations. Model estimates show that the property limit of 75 dBA will also be met. - Utilize E-coustic Criteria.

Prior to operation of the wind project, RSE recommends monitoring pre-development ambient sound levels at points representing nearby protected locations and during periods representing wind turbine operating conditions. Ambient sound level measurements will provide useful data concerning the contribution of non-turbine sound levels during future operation of the wind project.

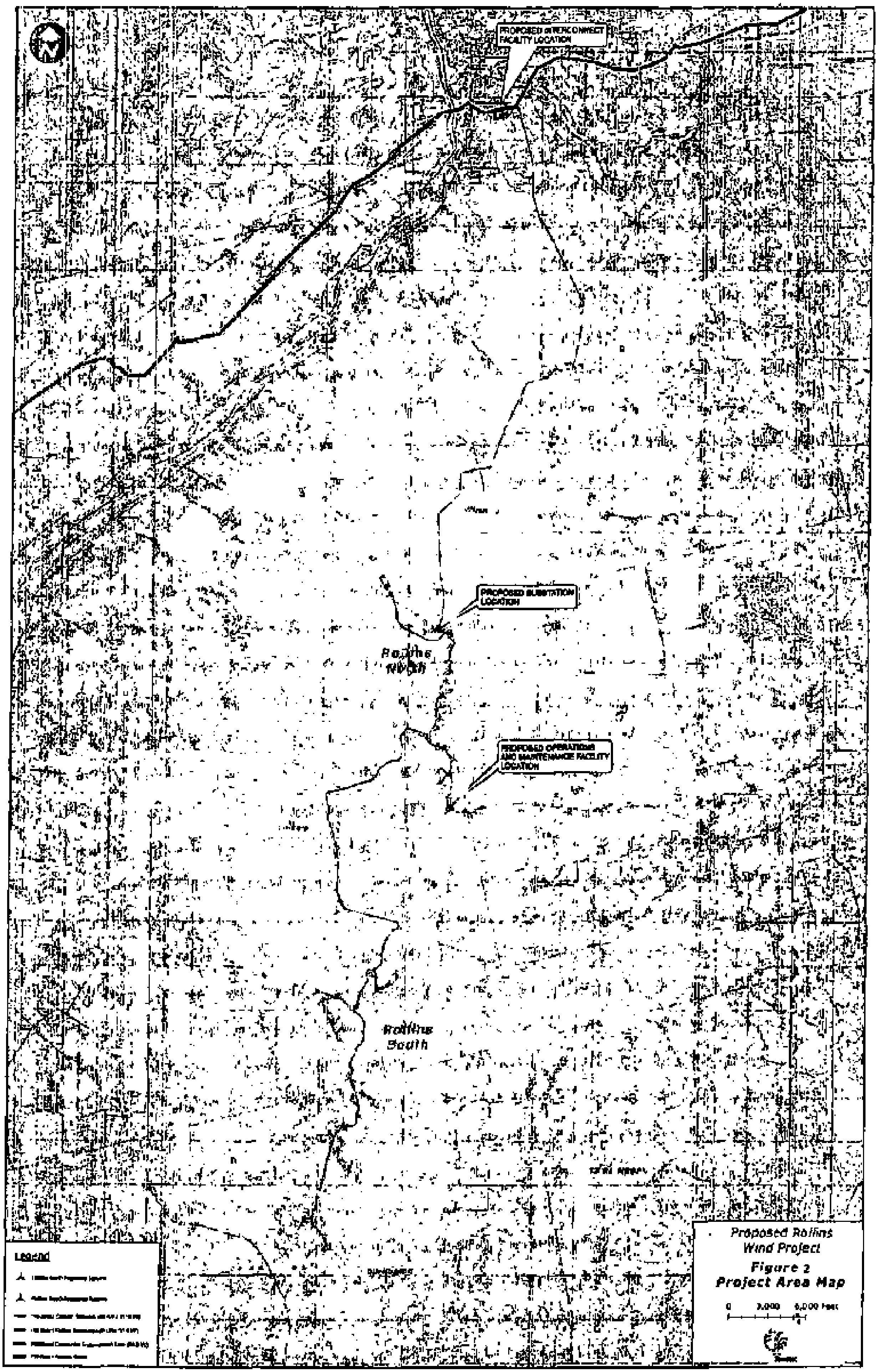
Once construction and startup of the wind project are complete, RSE recommends monitoring sound levels during routine wind project operations to verify compliance with relevant Maine DEP sound level limits.

No DbC used.
No current science used
Expediency used.

FIGURE 1
RELATION BETWEEN SOUND PRESSURE IN PASCALS AND SOUND PRESSURE LEVEL IN DECIBELS



Where is Dbc ?

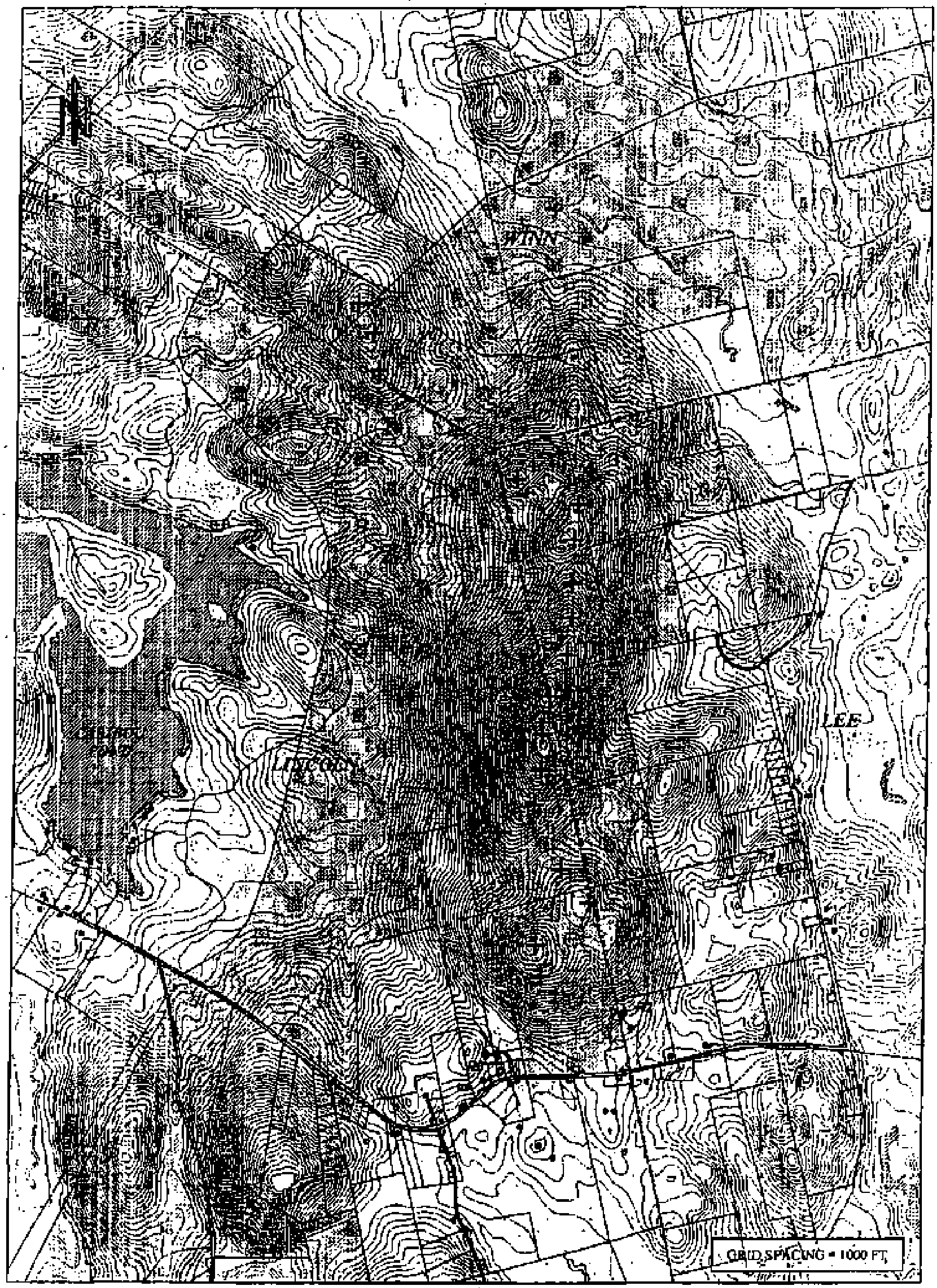


Proposed Rollins Wind Project

Figure 2 Project Area Map

FIGURE 3. VICINITY SITE PLAN (1 OF 2)

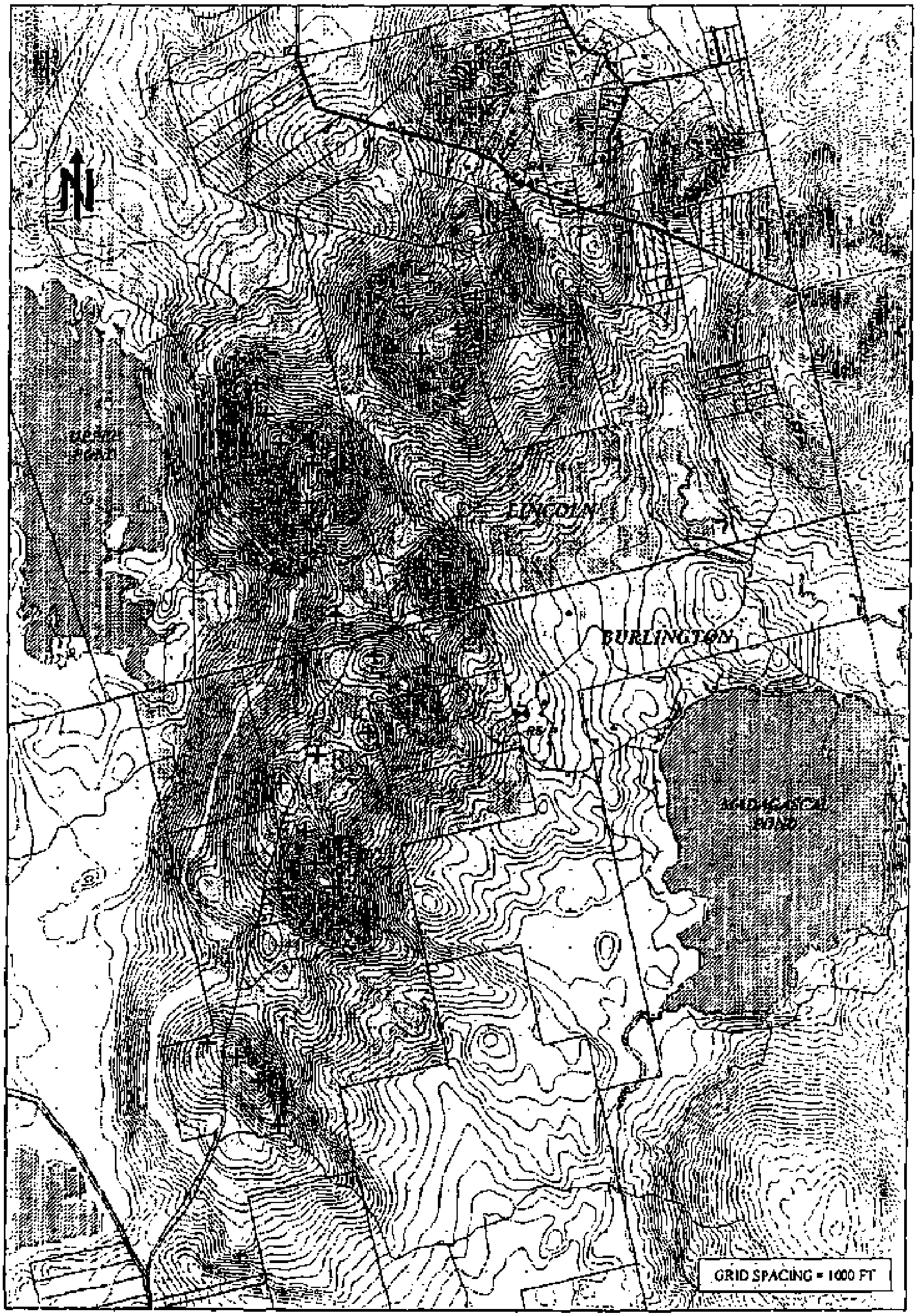
ROLLINS NORTH



WIND TURBINE LOCATION   DWELLING LOCATION   PARCEL WITH LEASE OR AGREEMENT

FIGURE 3. VICINITY SITE PLAN (2 OF 2)

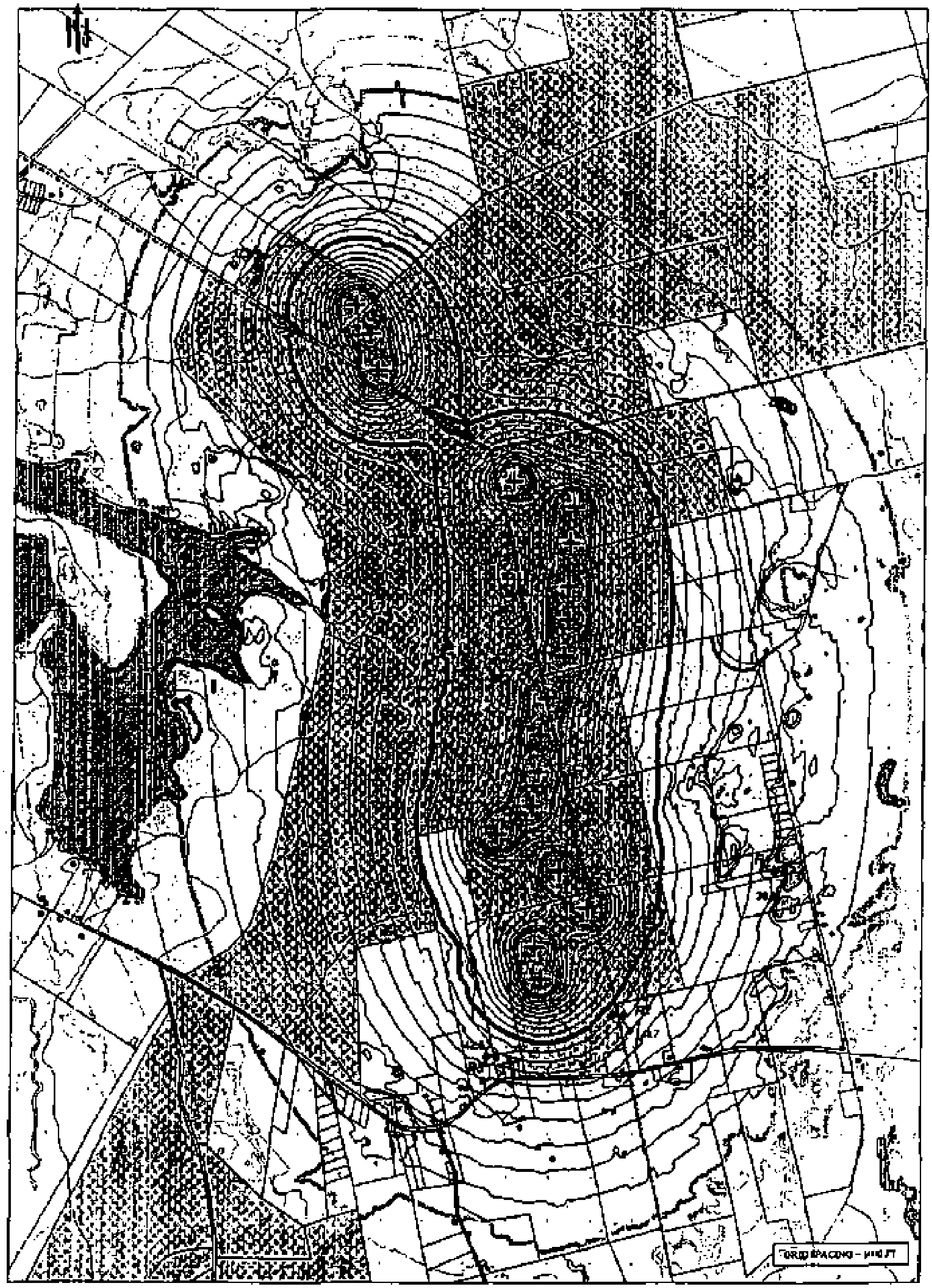
ROLLINS SOUTH



WIND TURBINE LOCATION
DWELLING LOCATION
PARCEL WITH LEASE OR AGREEMENT
BOAT LAUNCH

FIGURE 5. ESTIMATED SOUND LEVEL CONTOURS (1 OF 2)

ROLLINS NORTH



+ WIND TURBINE LOCATION

• DWELLING LOCATION

PARCEL WITH LEASE OR AGREEMENT

SOUND LEVEL CONTOUR
INTERVAL = 1 dBA

= 55 dBA (MDEP DAYTIME LIMIT)

= 45 dBA (MDEP NIGHTTIME LIMIT)

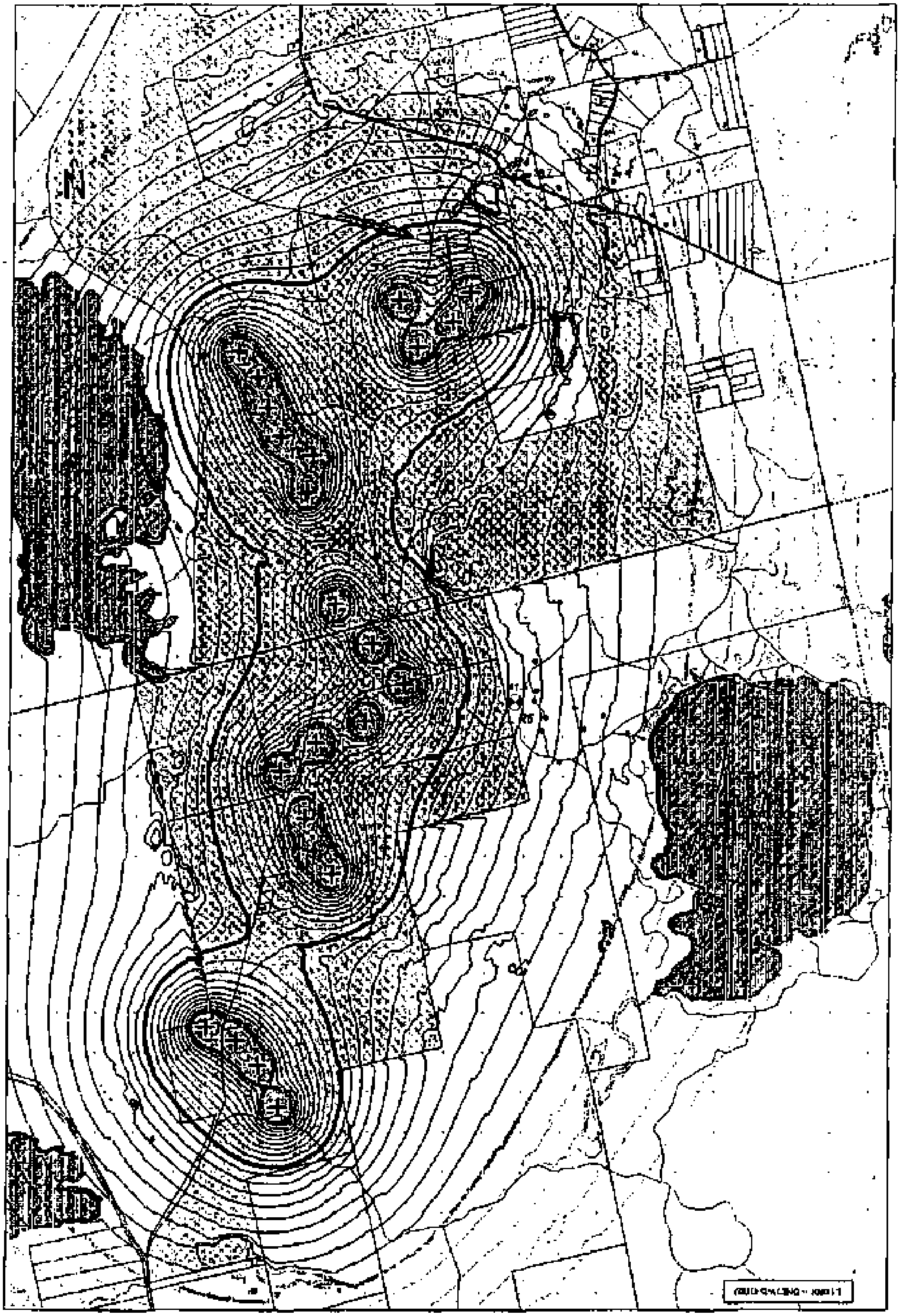
= 35 dBA

RECEIVER POINT &
ESTIMATED SOUND LEVEL

Appendix 5-2

FIGURE 5. ESTIMATED SOUND LEVEL CONTOURS (2 OF 2)

ROLLINS SOUTH



+ WIND TURBINE LOCATION   ● DWELLING LOCATION   ● BOAT LAUNCH   PARCEL WITH LEASE OR AGREEMENT

SOUND LEVEL CONTOUR
(INTERVAL = 1 dBA)

= 55 dBA (MDEP DAYTIME LIMIT)

= 45 dBA (MDEP NIGHTTIME LIMIT)

= 35 dBA

RECEIVER POINT & ESTIMATED SOUND LEVEL

DECLARATION OF COVENANT

THIS DECLARATION OF COVENANT is made by David and Willa Beitzel (collectively, "Grantor"), the owner(s) of a certain lot or parcel of land situated in the Town of Lincoln, County of Penobscot, and State of Maine, more particularly described in the deed dated December 15, 1983 and recorded at the Penobscot County Registry of Deeds in Book 3484, Page 115 (hereinafter referred to as the "Servient Land").

WHEREAS, **EVERGREEN WIND POWER III, LLC**, a Delaware limited liability company having a mailing address at c/o First Wind Energy, LLC, 85 Wells Ave, Suite 305, Newton, MA 02459 ("Grantee"), plans to construct and operate a wind power project, including wind turbine generators and towers and related equipment, facilities, infrastructure and substructures (hereinafter referred to as the "Wind Power Project"), on lands near the Servient Land, including (without limitation) the lands described on the attached Exhibit A;

WHEREAS, the Wind Power Project may include activities that produce annoyance, inconvenience, or discomfort to Grantor in connection with its use and enjoyment of the Servient Land; and

WHEREAS, Grantor has agreed to grant a perpetual negative covenant to Grantee, whereby Grantor covenants and agrees not to object to the Wind Power Project operations;

NOW, THEREFORE, for good and valuable consideration received, Grantor hereby grants a perpetual negative covenant to Grantee, whereby Grantor covenants and agrees for itself, its heirs, successors and assigns, not to object to the Wind Power Project, or to any activities arising from the construction or operation of the Wind Power Project that produce annoyance, inconvenience, or discomfort to Grantor in connection with its use and enjoyment of the Servient Land. Without limiting the generality of the foregoing, Grantor hereby: (a) agrees not to object to visual impacts, sound (including, without limitation, sound that exceeds otherwise applicable state or local maximum sound level limits for the Servient Land), shadow flicker, cell tower interference, or construction or operation impacts made or arising in connection with the Wind Power Project; and (b) waives, releases, and forever discharges Grantee from any action, claim, suit or proceeding in equity, law and/or administrative proceeding that Grantor may now have or may have in the future against Grantee (including, without limitation, any claim of negligence, public or private nuisance, trespass, or infliction of emotional distress) relating to any effect of the construction or operation of the Wind Power Project upon Grantor's use and enjoyment of the Servient Land.

This Declaration of Covenant shall extend to, be binding upon and shall inure to the benefit of heirs, personal representatives, successors and assigns of the parties hereto. The burden of the negative covenant hereby granted shall run with the Servient Land. The benefit of the negative covenant hereby granted is not appurtenant to any particular property, but shall be transferable in whole or in part, and may be sold, leased, assigned, pledged, and mortgaged by Grantee, it being the intent of the parties that such benefit may be transferred to any successors or assignees of Grantee that own or operate the Wind Power Project, as it may be modified, divided or expanded.

October 25, 2008

Ryan Chaytors
First Wind, LLC
85 Wells Avenue, Suite 305
Newton, MA 02459

Dear Mr. Chaytors:

This letter is to acknowledge that we are aware of the Rollins Wind Project proposed on property adjacent to our own on the Rocky Dundee Road in Burlington. We further have agreed to provide First Wind a sound easement on our property. It is our intention to finalize the documents memorializing that easement in the very near future.

Sincerely,

Ann Ele Warren

Doug Elkins

Ann Warren and Doug Elkins

WITNESS our hands and seals this 28 day of August, 2008.

In the presence of:

[signature]

[signature]

GRANTOR

Dave Beitzel
Print: David Beitzel

Willa C. Beitzel
Print: Willa Beitzel

STATE OF VT
COUNTY OF Rutland

August 28, 2008

Personally appeared the above-named David and Willa Beitzel and acknowledged the foregoing instrument to be his/her/their free act and deed.

Before me,

[signature]
Notary Public/Attorney-at-Law
Print Name: Mark Flynn
My Commission Expires: 2/10/11

The benefit of the negative covenant hereby granted may be enforced by Grantee, its successors and assigns, by any appropriate legal or equitable remedy. In the event that Grantee, its successors or assigns, shall bring an action against Grantor, its successors or assigns, by reason of a breach or violation of this negative covenant by Grantor, its successors and assigns, the substantially prevailing party in such action shall be entitled to recover their reasonable attorneys' fees and court costs incurred in such action from the substantially non-prevailing party.

[Remainder of Page Left Intentionally Blank.]

EASEMENT

THIS EASEMENT is made by WILLIAM R. WOTTON (collectively, "Grantor"), the owner(s) of certain lots or parcels of land situated in the Town of Lincoln, County of Penobscot, and State of Maine, more particularly described in the deed dated July 20th, 2005 and recorded at the Penobscot County Registry of Deeds in Book 10070, Page 242; and deed dated September 27th, 2006 and recorded at the Penobscot County Registry of Deeds in Book 10668, Page 177 (hereinafter referred to as the "Servient Land").

WHEREAS, **EVERGREEN WIND POWER III, LLC**, a Delaware limited liability company having a mailing address at c/o First Wind Energy, LLC, 85 Wells Ave, Suite 305, Newton, MA 02459 ("Grantee"), plans to construct and operate a wind power project, including wind turbine generators and towers and related equipment, facilities, infrastructure and substructures (hereinafter referred to as the "Wind Power Project"), on lands near the Servient Land, including (without limitation) the lands described on the attached Exhibit A; and

Should not be allowed

WHEREAS, the Wind Power Project will emit sound including at levels that may exceed applicable state or local maximum sound level limits for the Servient Land, and may cast shadows onto or produce a shadow flicker effect at the Servient Land;

NOW, THEREFORE, for good and valuable consideration received, Grantor hereby grants a perpetual easement to Grantee for: (a) the right to have sound generated from the Wind Power Project impact the Servient Land and exceed otherwise applicable state or local maximum sound level limits applicable to locations on the Servient Land; and (b) the right to cast shadows or shadow flicker from the Wind Power Project onto the Servient Land.

This Easement shall extend to, be binding upon and shall inure to the benefit of heirs, personal representatives, successors and assigns of the parties hereto. The burden of the easement hereby granted shall run with the Servient Land. The benefit of the easement hereby granted is not appurtenant to any particular property, but shall be transferable in whole or in part, and may be sold, leased, assigned, pledged, and mortgaged by Grantee, it being the intent of the parties that such benefit may be transferred to any successors or assignees of Grantee that own or operate the Wind Power Project, as it may be modified, divided or expanded.

The benefit of the easement hereby granted may be enforced by Grantee, its successors and assigns, by any appropriate legal or equitable remedy. In the event that Grantee, its successors or assigns, shall bring an action against Grantor, its successors or assigns, by reason of a breach or violation of this Easement by Grantor, its successors and assigns, the substantially prevailing party in such action shall be entitled to recover their reasonable attorneys' fees and court costs incurred in such action from the substantially non-prevailing party.

WITNESS our hands and seals this 23rd day of October, 2008.

In the presence of:

GRANTOR

Print: William R. Wotton

STATE OF New Hampshire
COUNTY OF Strafford

10/23/08, 2008

Personally appeared the above-named William R. Wotton and acknowledged the foregoing instrument to be his/her/their free act and deed.

Before me,

Notary Public/Attorney-at-Law
Print Name: Andrea L. Rogers
My Commission Expires: 09/19/2012

Submitted 2/11/09 [signature]

DEP Testimony , February, 11, 2009
From:
Gary Steinberg, Doctor of Dental Medicine, DMD
BA Chemistry/Biology(Electrical Engineering background)
A past United States Public Health Service Commissioned Officer (04 Rank)

Dental Turbine Demonstration NOISE > 150hz, with amplitude modulation component.
DbA for short duration

Head set, Noise Cancellation…why ?
Relation to Military and Submairine, Aircraft, ships, Enclosed environment. Low frequency droning, with high immission.

Low Frequency Components best measured with DbC. The best inclusive measurement of > 30Hz
DbC

Current State regulations under Chapter 375 MRSA, section 343 are non-specific as related to the wind turbine noise, its amplitude modulation components, and indeed sorely lacking for Industrial Wind Siting. Turbines were not in large use when the regs were designed, and are not applicable to this Industry in the regulations generalities.

Why?..
By utilizing all Dba Readings and having total Neglect of Dbc, the area proven to affect humans, the impacts are neglected and minimzed..
DbC is the most accurate, inclusive noise reading of Hz affects, it is perceptual , measuring more accurately the human impact do to the immission affective noise on humans by these massive turbines.

Grinding of Bone v Turbine low frequencies 30-170 Hz, permeating the air and Ground.even with anesthesia, you feel the vibrations , even if anesthetized.

Effects as they relate to humans…….Being numb helps, but the vibrations still are felt by the humans…How about the effects from prolonged exposure to that sound,?

Immissions are very strong from Massive Turbines, in the DbC range, wind turns turbines by external wind energy, Dental handpieces are wind turned, but it internally.

Site Noise –Con 2008 information, several examples, Time permitting

Insert here applicable noise issues from Noise-Con 2008 conference(Time permitting)

Bad Science is now used for siting , and Regulations are not using current Science of DbC and low frequency effect to Humans.

Firstwinds application is computer modeled DbA, based on poorly designed science,designed by the same industry that benefits from neglecting DbC use and proper setbacks. Neglecting application of present Science and effects of DbC when used in modeling, terrain, geography of terrain, and acoustic effects,, the science is *Skewed for application by this industry,it is not-independently reviewed. It* represents vested interest studies for the industry, not for Public Protection. Setbacks are inadequate , DBa levels allowed are extreme for rural areas(18-25 Dba typical),(DbC is not even thought of) and Dr. Pierpoint's WTS is real, and now confirmed by recent research. (included).

The more inclusive DbC MUST BE USED AND BUILT INTO THE LAW for Siting and Safety.

This area, Lincoln lakes is much akin to living in a Bowl with an Island in the middle. Noise carries unattenuated in Lake regions on both side of geographic ridgeline, and is refracted, , reflected from mountain terrain, making it worse.There are hundreds of properties affected. Noise, Reverberating with little attenuation. Do you think hundreds of property owners will tolerate this , knowing the facts of this project and the effects on their lives and properties.Indeed, Low frequency Dbc penetrates wood structures easily, unattenuated. Houses are permeated by high immission low hz noise, with little reduction 24/7/365.
Time limits are needed for military exposure to DbC effects in military vessels where DbC has been studied . Exposure time limits are mandated in the military for such exposure.But humans may be exposed to this turbine noise in the environment here 24/7/365, at random extended periods by massive wind turbines, at high immission levels of DbC..

But imagine living near Turbines 24/7, with Low Freq DbC.
Lake areas on two sides of á n/s ridge, highly populated and inside hills, This is the setting for problems waiting to happen, and future prolonged litigation and potential human damage.

Add to this certain weather conditions(quiet summer eve with winds aloft able to drive turbines) and low ambient noise below(18-25Dba ambient) in these areas at that particular time, and you have a disaster, with human effects, and destruction of the rural environments., with health effects, ruining the reason people live here and purchase property for their happiness.

Correspondence between A. Fisk and D Littell, show weakness Of Maine DEP regulations an non . utilization of good science, as represented by Kamperman and James of E-coustics(see critique). ,Old regulations of DEP, non-specific to the siting of these machines, are not safely applicable. Nowhere are DbC levels used, the noise that affects humans the most .

However, Wind Siting Sound measurements for siting and protection of the public in Rural areas must be done, with real science.,This is not rocket science, it is basic science. It is Straight forward when properly applied and executed...See Kamperman/James/E-coustics. Info enclosed.

The poor modeling data used by RSE, designed for the industry , utilized by this DEP application, is not good science, it is industrial designed Pseudo-Science. Where is the DbC? As the saying goes for modeling with computers, JUNK IN, JUNK OUT!.
Set back data is completely inadequate. The industry legally limits suit to close abutters. They know noise is a serious issue for their industry. They know they must bend data to install turbines in a given area, for the maximal profit in a non-profitable industry that can't exist unless it has large support from your tax dollar..

DbC it has been around for decades, is the proper way to measure perceived noise , and must be used.It is not rocket science, nor is it difficult to apply !

Finally ,low ambient noise in rural areas, at lower elevations, creates an issue when turbines run in the PM and early AM, with hill wind above, and calm, low ambient noise present below, DbA<25 , creating a very bad noise issue in this terrain with numerous non noise- attenuating lake bodies on two sides .see Van den Berg study.

Contrary to the industries wishes ,

Turbine Health affects are real. Dr. Pierpoints book, and a NEW STUDY I have included , verifies that WTS is real, and humans are very effected by it.An important news study, based on the Human Vestibular System Research on low frequencies by Todd, Rosengren, and Colebatch...August, 2008, proves this as well.(enclosed).

Dr. Pierpoint's study on WTS , and other research is peer reviewed, and valid.It must be used, and applied.
The science is here , the equipment is here and readily available for measurements , the research is real. DbC meters have been around for decades, but for some reason, the industry wont use them . I wonder why...?.Why is the DbC button(right here), not being pressed?

Finally , as a health care practitioner, if I had the science, didn't apply it appropriately, expedited my operations on humans for politicized process ,it would

not only be against my professions code of conduct and ethics, it would be immoral and illegal. It would be malpractice.
To not use the best research that you have , to use weak research and outdated , regulations in an expedited manner designed by the same people pushing the process, is akin to what I have stated above. In the least, it is a breach of Citizen Trust and Your Mission as the Dept. of Environmatal Protection in this state.

You have the mandate , and the mission in this state, to protect the environment, and its inhabitants, along with The Dept of Human Services.DHS must be involved in this process as well.
You have a serious mission, not to be Expedited!: demanding the highest standards for the citizens, (not Wind Corporations) .

And I will add this as well..And I site the following.

From the Constitution of the State of Maine, Article I.

"All power is inherent in the people; all free governments are founded in their authority and instituted for their benefit; they have therefore an unalienable and indefeasible right to institute government, and to alter, reform, or totally change the same, when their safety and happiness require it."

All citizens in this state will assert their Rights..

Press the C button! (from digital DB METER used in testimony in my Hand)

Attached documentaton.
1.How to Guide on Siting Wind Turbines to Prevent Health Risks FROM SOUND
George Kamperman, Richard James (E-Coustic Solutions)
2.Propagation of Noise From Wind Turbines on-shore and off-shore
Bo Sondergaard, Delta Danish Electronics, Light and Acoustics www.delta.dk
3.Noise Radiation From Turbines Installed Near Homes, Effects on Health
FreyBA,MA, Hadden Bsc,FRICS June 2007 (full .pdf to be forwarded)

4.Renewable Portfolio Standards.
5.Noise-Con 2008, July 28-31, Dearborn Mich.
6.Fisk / Littell comments with E-coustic Commmentary
7. E-coustics replies letter
8. Chapter 375, sec 343 commentary Dr G steinberg notes
9.Firstwind DEP submission application Section 5 , Section 27 with commentary, Dr G. Steinberg
10.Rumford hospital CALL FOR MORATORIUM TO EVALUATE HEALTH RISKS FROM INDUSTRIAL WIND TURBINES...e-mail release enclosed.

Submitted 2/11/09

Maddox, Becky

From: Maddox, Becky
Sent: Tuesday, February 17, 2009 8:30 AM
To: 'Warren Brown'
Subject: FW: Please add to my testimony

Attachments: Windfarm noise[1].pdf

Windfarm
ise[1].pdf (988 KB)

Warren,
Please add this to the information that I sent to you last week regarding the noise questions/concerns and studies.

Thanks,

Becky

-----Original Message-----
From: GNS [mailto:gernish@yahoo.com]
Sent: Sunday, February 15, 2009 9:00 PM
To: Maddox, Becky
Subject: Please add to my testimony

Hello Becky,
Please include this PDF file with my information from 2/11/2009 testimony. It has important information for DEP review. Thank you..
Gary Steinberg DMD

This is the end of the mail from GNS...

NOISE RADIATION FROM WIND TURBINES INSTALLED NEAR HOMES: EFFECTS ON HEALTH

With an annotated review of the research and related issues

By Barbara J Frey, BA, MA and Peter J Hadden, BSc, FRICS

February 2007
June 2007
www.windturbinenoisehealthhumanrights.com

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Contents

Note: This paper limits its discussion to wind turbines taller than 50m or from 0.75MW up to 2MW installed capacity.

Section 1.0 ABSTRACT

Wind turbines are large industrial structures that create obtrusive environmental noise pollution when built too close to dwellings. This annotated review of evidence and research by experts considers the impact of industrial-scale wind turbines suffered by those living nearby. First, the paper includes the comments by some of the families affected by wind turbines, as well as coverage in news media internationally. The experiences described put a human face to the science of acoustics.

Second, the paper reviews research articles within the field of acoustics concerning the acoustic properties of wind turbines and noise. The acoustic characteristics of wind turbines are complex and in combination produce acoustic radiation. Next, the paper reviews the health effects that may result from the acoustic radiation caused by wind turbines, as well as the health effects from noise, because the symptoms parallel one another. Primarily, the consequent health response includes sleep deprivation and the problems that ensue as a result. In addition, this paper reviews articles that report research about the body's response not only to the audible noise, but also to the inaudible components of noise that can adversely affect the body's physiology. Research points to a causal link between unwanted sound and sleep deprivation and stress, i.e., whole body physiologic responses.

These injuries are considered in the context of Human Rights, where it is contended that the environmental noise pollution destroys a person's effective enjoyment of right to respect for home and private life, a violation of Article 8 of the European Court of Human Rights Act. Furthermore, the paper considers the consequent devaluation of a dwelling as a measure of part of the damage that arises when wind turbines are sited too close to a dwelling, causing acoustic radiation and consequent adverse health responses.

The review concludes that a safe buffer zone of at least 2km should exist between family dwellings and industrial wind turbines of up to 2MW installed capacity, with greater separation for a wind turbine greater than 2MW installed capacity.

Section 2.0 INTRODUCTION

1 Industrial wind turbines produce an intermittent flow of electricity but in the process also produce undesirable noise emissions when installed too close to people's homes, causing environmental noise pollution. (See Section 6.5 of this paper.)

2 Wind turbines located at a sensible distance from dwellings are unlikely to cause environmental noise pollution and health problems. When the State allows priority to commercial interests, the reasonable needs of families and their human rights are extinguished. There are questions of human rights and of industrial and governmental ethics when developers construct wind turbines too close to dwellings, especially when Government decision makers are fully aware that there is a high probability that families may lose the right of respect for their home and private life. In such instances, both the commercial groups and the State are party to the violation.

3 This Review seeks to bring together research evidence in the professional literature that addresses the substantive nature of the problem, both from the acoustical and biomedical perspectives. However, the Review would be incomplete without Section 3, Overview of the Problems – Personal Perspectives, which includes the observations and reflections by those living near wind turbines, as well as reports in the media. The Review also considers the possible infringement of human rights when developers build wind turbines in close proximity to dwellings.

4 Precision in predicting noise levels in homes neighbouring wind turbines has so far eluded the wind industry. As early as 1987, Glegg, Baxter, and Glendinning reported on the problems with predicting noise accurately:

> *'This paper describes a broadband noise prediction scheme for wind turbines. The source mechanisms included in the method are unsteady lift noise, unsteady thickness noise, trailing edge noise and the noise from separated flow ... [In] spite of these detailed predictions of the atmospheric boundary layer the noise predictions are 10dB below the measured levels ... [The upwind] support tower cannot be ignored, since significant acoustic scattering occurs when the rotor blade is close to the tower. This can be very important subjectively and so a theoretical model has been developed which allows for the increase in radiation due to this effect.'* [Glegg SAL, Baxter SM, and Glendinning AG. The prediction of broadband noise from wind turbines. Journal of sound and vibration 1987; 118(2): 217-39, pp 217-218]

5 In a recent (2006) Report the Dti found further studies of wind turbine noise were necessary:

> *'However, the presence of aerodynamic modulation which is greater than that originally foreseen by the authors of ETSU-R-97, particularly during the night hours, can result in internal wind farm noise levels which are audible and which may provoke an adverse reaction from a listener ... To take account of periods when aerodynamic modulation is a clearly audible feature within the incident noise, it is recommended that a means to assess and apply a correction the incident noise is developed.'* [Dti Executive

Summary of the Measurement of Low Frequency Noise at Three UK Wind Farms, contract number W/45/00656/00/00, URN number 06/1412, Contractor: Hayes McKenzie Partnership Ltd, 2006.]

The report states that '... *it may be appropriate to re-visit the issue of aerodynamic modulation and a means by which it should be assessed.*' [p 65]

6 The wind energy industry and its consultants – acoustical engineers – claim that the audible and inaudible noise effects have minimal consequence on humans and that infrasound (0Hz – 20Hz, part of the low frequency noise spectrum), is inaudible and weak and therefore not a human health risk. This review has not found any epidemiological evidence to support these suppositions.

7 As more wind turbines are installed near homes, more communities are affected by these complex sounds. Noise is the human face of the science of sound, and physicians are seeing the results. More people living close to wind turbines – within 1.5km – complain of sleep deprivation, headaches, dizziness, unsteadiness, nausea, exhaustion, mood problems, and inability to concentrate.

Physicians and researchers in the UK, Portugal, Germany, the USA, Australia, and New Zealand, among others, have observed a similar constellation of symptoms.

8 Although acousticians and engineers working for the wind energy industry conclude that audible noise and low frequency noise from wind turbines are unlikely to cause health effects, experts in biomedical research have drawn different conclusions.

9 Indeed, in 2006, the French National Academy of Medicine issued a report that concludes:

> *'The harmful effects of sound related wind turbines are insufficiently assessed ... People living near the towers, the heights of which vary from 10 to 100 meters, sometimes complain of functional disturbances similar to those observed in syndromes of chronic sound trauma ... The sounds emitted by the blades being low frequency, which therefore travel easily and vary according to the wind, ... constitute a permanent risk for the people exposed to them ... An investigation conducted by the Ddass [Direction Departementale des Affaires Sanitaires et Sociales] in Saint-Crepin (Charent-Maritime) revealed that sound levels 1 km from an installation occasionally exceeded allowable limits.'*

The report continues:

> ***'While waiting for precise studies of the risks connected with these installations, the Academy recommend halting wind turbine construction closer than 1.5 km from residences.'***
>
> [Chouard C-H. Le retentissement du fonctionnement des eoliennes sur la sante de l'homme (Repercussions of wind turbine operations on human health). Panorama du Medecin, 20 March 2006]

10 Warning signs of future problems with new technologies have been overlooked or ignored in the past, much to the detriment of the public's health. One has only to look at the history of asbestos and mesothelioma; tobacco and lung cancer and chronic pulmonary diseases; thalidomide and birth defects; mercury and neurotoxicity; x-rays and fluoroscopes and cancer; lead-based paint and childhood poisoning; and coal miners and black lung, to name but a few. The pattern of medical problems took time to emerge before a pattern of health complaints were observed, followed by epidemiologic studies and public health policy.

11 Human health effects may take years to emerge as a pattern, when the detrimental effects are past correction. As the numbers of wind turbine installations close to people's homes increase, reports of health effects have escalated, from sites across the globe. These problems do not appear to be present where wind turbines are located at a safe distance from homes.

12 This paper brings together research evidence on the characteristics of noise radiated by wind turbines and how that noise affects human health. As this is a public health issue, this paper also presents the advice and policy recommendations of medical and epidemiological experts.

This paper also considers whether as a result of reported health problems, the noise emission components of wind turbines should be regarded as an environmental noise pollution, which is a violation of basic Human Rights.

Section 3.0 OVERVIEW OF THE PROBLEMS: Personal Perspectives

'Britain should be considerably quieter than it is ... unless something is done the situation will soon become intolerable.' **[The *Times*, London, 3 July 1963]**

1 This section of the paper, perhaps more than any other, illustrates that noise is the human face of the science of acoustics. This section presents that essential – but often ignored – side of the equation: the voices of those directly affected by the construction of wind turbines near their homes.

2 In 1966, Dr Alan Bell observed that noise is much more than an occupational hazard:

> *'Noise is a sensory input, devoid of information, that nevertheless demands attention ... it is a public nuisance and a danger to mental and physical health ... The degree of annoyance is not necessarily directly related to the intensity of the sound ... The factors influencing community responses included lack of sleep ... The results of past lack of forethought are aggravated by situations still developing that will certainly create noise problems in years to come ... Even rural peace is often shattered.'* [Bell, A. Noise: an occupational hazard and public nuisance. Geneva: World Health Organization, 1966.]

3 Both the European and British Wind Energy Associations, in their Best Practice Guidelines, state that:

> ***'Wind turbines should not be located so close to domestic dwellings that they unreasonably affect the amenity of such properties through noise, shadow flicker, visual dominance or reflected light.'***

4 But these are only industry guidelines. Planning Policy Statement 22, section 22, says that:

> *'Renewable technologies may generate small increases in noise levels (whether from machinery such as aerodynamic noise from wind turbines, or from associated sources – for example, traffic).*
>
> ***Local planning authorities should ensure that renewable energy developments have been located and designed in such a way to minimise increases in ambient noise levels.***
>
> *Plans may include criteria that set out the minimum separation distances between different types of renewable energy projects and existing developments. The 1997 report by ETSU* [ETSU-R-97, The assessment and rating of noise from wind farms] *for the Dti should be used to assess and rate noise from wind energy development.'*

5 This guidance is scrupulously followed by wind turbine developers and Planning decision makers. Section 4.0 of this paper, Acoustics, addresses the limitations of ETSU-R-97; yet it is interesting to note here that the standards in ETSU-R-97 appear to provide less protection to people than the standards of the World Health Organisation *Guidelines for Community Noise 1999*.

6 ETSU-R-97 and subsequent policies based on that document fail to protect families living near wind turbines, as the following illustrates:

For a fortnight beginning 12 January 2004, complainants and witnesses gave evidence about their experiences living near the Askam, Cumbria, UK, wind turbines. These wind turbines are rather modest compared to the larger turbines of today: seven wind turbines, each 62.5m high.

Prior to the construction, the developers had assured the community that wind turbines near their homes would not create noise or visual disturbances. Background noise prior to the wind farm was as low as 16.5 dB, with a nighttime average of about 19 dB. The readings are now regularly in the middle to high 40's dB.

> *'Eventually the developers admitted everything that we had claimed – but still nothing has been done to resolve these problems to the satisfaction of those people who matter.'* [Brierley D., *Public Presentation,* Askam, Cumbria, 2006]

7 On seeking assistance from the local Council, the Askam residents were then informed that *'because of the court case of **Gillingham v Medway Council**, the classification of the area had changed with the passing of the planning permission'*. That is, the area where the wind turbines were built had been reclassified as a mixed rural/industrial area; local residents were unaware of this reclassification.

Consequently, their expectations of noise levels were considered *'unrealistically high'* for an industrialised area, according to the local authority. [Brierley, 2006]

8 Indeed, when the Askam residents brought a case against the developer PowerGen (E.oN), the judge eventually ruled against the residents, saying that ***"audibility and annoyance are not to be equated with nuisance."*** [Brierley D., *Public Presentation,* Askam, Cumbria, 2006]

9 The following are excerpts of statements of only a few who have lived near wind turbine installations. Some of these families have consequently moved home because they felt it impossible to enjoy a normal family life by remaining.

It is important to remember that some of these statements were written or presented several years after living with the daily, or nearly daily, intrusions of noise and/or shadow flicker / strobing caused by wind turbines.

Please note: In respect for the residents' confidentiality, the authors are identifying the families by number rather than by name.

10 *'Everything changed ... when the wind turbines arrived ...approximately 700 metres away from our property ... At this point we had no idea how this development (windfarm) was to effect [sic] our quality of life and cause so much pain and suffering. Within days of the windfarm coming into operation we began to hear a terrible noise, but didn't know, at first, where it was coming from. As it continued we eventually realised the noise originated from the windfarm. We were horrified. Were we the only ones suffering this noise?*

Would this continue for the proposed length of time the windfarm would be there i.e. for the next 20 years? The noise drove us mad. Gave us headaches. Kept us awake at night. Prevented us from having windows and doors open in hot weather, and was extremely disturbing.'
Member of Family 01

Some time after the wind turbines began operation, this resident learned that other people were experiencing the same problems; they attempted to voice their concerns and their distress:

'From that day, until the present, despite telephone calls, letters to, (and liaison meetings with), the owner, the operators, representatives of the Parish Council, the District Council, the local Planning Committee, the Environmental Health Department and our member of Parliament ... nothing has been resolved.'

11 On one occasion, several of the wind turbines were switched off on the morning of one bank holiday, to give this family some relief (this is 4 years on ...), but by evening, the turbines were operational, and the noise returned. This resident's statement continues with an anecdote: one of the wind turbine operators who lived several kilometres from the site said

'... quite openly, that he walked his dog on the foreshore ... and had identified noise from the wind turbines ...over 4 kilometres away from the site.'

Occasionally the family would request that one or more turbines could be switched off so that they could spend time in their garden, but:

'I found it beyond belief that after almost 4 years we still had to ask for time to work in our own garden and even then to be restricted to 4-5 hours.'
Member of Family 01

12 Other witnesses said that even without a view of the turbines, there is an audible impact:

'I cannot come to terms with the thought of this situation continuing for another 15 years. From our property we cannot see any of the turbines, but we can certainly hear them.' **Member of Family 02**

'They were noisy immediately, blades "whooshing" around ... if the wind is from the East, or the South, the noise is horrendous. You can't get away from the noise, where can you go? It's all around outside and you get it inside the house as well. It's worst during the night, I have to "bed hop" to get any sleep ... but it doesn't work ... This noise is like a washing machine that's gone wrong. It's whooshing, drumming, constant drumming, noise. It is agitating. It is frustrating. It is annoying. It wears you down. You can't sleep at night and you can't concentrate during the day ... It just goes on and on ... It's torture ... [4 years later] *You just don't get a full night's sleep and when you drop off it is always disturbed and only like "cat napping". You then get up, tired, agitated and depressed and it makes you short-tempered ... Our lives are hell.'* **Member of Family 03**

13 One resident near the wind farm, a mechanical engineer and his family, accepted the developer's assurance that the turbines would not be a noise nuisance. However, when the wind turbines became operational, they began to experience problems with noise. Following this, they then discovered that other families had similar problems. The developer denied that any problem existed:

> *'The wind farm was described as "inaudible", which clearly wasn't true. They also denied the existence of upwind noise, a fact they later retracted and admitted did exist ... at one of these meetings Mr ---, of ---, said ... that his company was not prepared to take any action to reduce or eliminate'* the phenomenon of shadow flicker. *'Throughout the negotiations with the developer's side, it has been disappointing to encounter the amount of "stonewalling" and intimidation, which culminated in the threat of legal action against us, when our sole intention was to remedy the problems inflicted on us by the presence of the wind farm, which caused the various nuisances.'* **Member of Family 04**

14 Another family living near the wind turbines, who had also been reassured by the developer prior to the installation that noise would not be a nuisance, did indeed experience a 'noise nuisance' when the turbines became operational. At a meeting, a representative of the developer, when asked about the problems with noise, especially after assurances that noise would not be a problem at this site, responded:

> *'... no wind farm was "inaudible". I suggested that any further correspondence publicising wind farms in general should, in future, be correctly worded and not mislead the general public in this way ... everything we were complaining about was being aggressively fought against by the developers ... My personal feeling is that the residents have been let down by all the parties involved, but specifically by the Environmental Health Department's apparent inability to resolve what is a genuine and distressing sequence of noise nuisances that have gone on now for over 4 years.'* **Member of Family 05**

15 Yet another resident living near the wind turbines, although not visible from his home, found the noise from the turbines disturbing, especially when the wind prevails from the East, which is frequent:

> *'It was like the Chinese water torture, it was constant pulsating noise. I also had to move bedrooms on occasions in an attempt to escape the noise. It's a feeling as much as a noise ... It's an irritating and tiring noise, especially when you have not had any sleep because of it.'* **Member of Family 06**

16 The litany continues: One resident, with many years work experience of oil and gas exploration, development, and production, including work as a consultant internationally, questioned the wisdom of installing wind turbines near homes. It was not the technology to which he objected. However, he felt reassured by the developer that the wind turbines would not create a nuisance, and that the developer would safeguard their 'continuing quality of life':

> *'It is not necessarily the noise level per se, but the nature of this noise. It may not be constant. It has lasted some 10 – 12 days without respite, with varying intensity such that even when not present you are waiting for it to re-occur.*

The most apt description is that it is an audio version of the Chinese Water Torture. The noise is such that the noise is felt as much as heard ... Developers have been informed ... that this noise is making people ill, although I have no experience of this. This, I believe, may be attributable to the low frequency element of noise created by the wind farm. This phenomenon is documented in a report published by DEFRA, where wind farms are confirmed as a source of low frequency noise.'
Member of Family 07

This particular resident was 'appalled' when the signatory of the developer's letter assuring the community that the wind turbines, when operational, would not create a noise nuisance, later admitted to him privately, that:

'There is noise with all wind farms. It is to be expected and you have to live with it.'

'This confirmed my worst fears that the residents had been misled ...'

17 Apparently, the developer eventually provided attempts at noise mitigation:

'This, I believe, is an admission that noise problems exist ... the developers want to dictate the times of day, duration and location of the residencies [sic] that will and will not be affected by noise emanating from their wind farm. This is entirely contrary to the [developer's] letter and the BWEA and EWEA guidelines ... It is also contrary to the EHO's mission statement as publicly depicted on their web site.' **Member of Family 07**

18 And from a farming family:

'The noise is a big "Whooshing" noise ... I hear it inside my home ... If I sit in the garden it's there, not always as it depends really on the wind direction and if the wind is from the west side of my property it is worse ... I am not against wind energy, but these are definitely in the wrong place. If only someone had come and looked at it or even if they came today, they would realise what I am trying to say.' **Member of Family 08**

19 **One family has since moved away; their home was 680m from the nearest wind turbine.**

Another family that has since moved away lived 700m from the nearest wind turbine.

Another family is moving away; they live 800m from the nearest turbine.

Of the other witnesses, distances from the nearest turbines range from 600m to 1000m. One resident, who lives 390 m away, sleeps with the radio on, but this person declined to testify.

20 **In a paper known as "The Darmstadt Manifesto", published in September 1998 by the German Academic Initiative Group, and endorsed by more than 100 university professors in Germany, the German experience with wind turbines is described in graphic terms:**

'More and more people are describing their lives as unbearable when they are directly exposed to the acoustic and optical effects of wind farms. There are reports of people being signed off sick and unfit for work, there is a growing number of complaints about symptoms such as pulse irregularities and states of anxiety, which are known to be from the effects of infrasound [sound frequencies below the normal audible limit].'

21 In Bradworthy, North Devon, UK, noise complaints lodged to the local environmental health officer after three wind turbines – each 85m high [75m approved, built at 85m] – became operational in 2005, are still unresolved. One resident, who lives as near as 533m to these three turbines, endures

> *'strobe or shadow flicker entering my Kitchen, Conservatory and Sitting room, all on the East side, when the sun rises in the east, in Autumn and Winter behind the wind turbines. This will last for three months and is NOT ACCEPTABLE ... The prolonged flicker causes a headache, affects my eyes and causes disorientation.'*

This resident has observed and described the noise at various times of day, in all weather conditions, and rarely is there a lull in the noise, which is characterised, depending upon the strength and direction of the wind, as swooshing, swishing, whining, a constant aeroplane drone, a police siren, and like a spin dryer.

> *'That shadow flicker would cause problems was denied 3 times in the planning appeal book.'* [MH, Bradworthy]

Yet, the developer's Planning Appeal stated:

> ***'Shadow Flicker. As previously stated, this is not considered an issue due to the distance and orientation of the turbines to the nearest dwelling.'***

Instead, this property owner explains that the shadow flicker *'actually reaches past my property and over a public highway ... 500 metres away is too close.'* [MH, Bradworthy]

22 In a letter to the *Western Morning News*, 16 October 2001, Patrick and Phoebe Lockett, of Wadebridge, Cornwall, UK, wrote:

> *'We live near the Bears Down windfarm in North Cornwall, where there are 16 turbines between 750 and 1400 metres from our home, and we are subjected to intrusive noise. When the wind direction is south to south-westerly, there is a rhythmic thumping sound which disturbs us and our neighbours, in our homes and gardens, day and night.*
>
> *We are writing to residents in the areas of North Devon where there are proposed wind farm developments, advising them not to take reassurances from developers at face value.*
>
> ***I quote from a letter we received in October 1998 from National Wind Power's head of operations and technology, John Warren:***
>
> **"We are 100 per cent confident that there will be no noise problem at any nearby residence."**

NWP say that they do not know why the turbines are making this noise. They are monitoring it and tell us they will try some experimental adjustments to the turbine blades. Our only hope is that NWP's investigations will provide a solution to the distressing situation in which we and our neighbours find ourselves.'

23 Two years later, in a letter to the Western Morning News on 15 November 2003, Phoebe Lockett wrote:

'We are still experiencing noise problems with the turbines on Bears Down.'

24 *The Courier-Mail* (Queensland, Australia) reported on 4 October 2005, that a Queensland government-owned wind farm, which began operating in 2000, was creating sleep disturbances and noise problems at nearby properties. Jim and Dot Newman said:

'... the throbbing, thumping noise from the generators could be heard at all hours of the day. It was very frustrating in the beginning and makes us extremely upset, but there is nothing we can do about it.'

After a year, the couple decided to move, but could not find a buyer for their property. The newspaper reported that:

'A number of Victorian residents know exactly how the Newmans feel and are equally angry at Stanwell Corporation.'

Stanwell had assured residents that they would not be disturbed by the turbines.

With two 60m towers standing 750m and 810m from their homes, Keith and Terry Hurst said:

'It was terrible, we had real trouble sleeping and the worst part was we decided to move and it took 18 months to sell the place.' In a 'booming' property market, they lost money selling their house. One real estate agent said that 'it was nearly impossible to sell a property within one kilometre of a wind turbine or a proposed wind turbine.'

25 Stanwell's spokesperson said that:

'... independent experts and noise level monitoring had verified the Toora Wind Farm [as] fully compliant with its operating permit conditions.'
(Gregg N. Wind energy not resident-friendly. The Courier-Mail, Queensland, Australia, 4 October 2005.)

26 A common thread runs through these observations by those who live near wind turbines: It is not necessarily only the loudness of the noise; it is also the character of the noise that is disturbing. The wind turbine noise is periodic; intermittent; 'whooshing' or 'swishing'; it interferes with outdoor activities at one's home and with sleep or studying, i.e., it severely disrupts normal family life.

As one of those living near the wind farm in Askam observed:

> ***'You think "Oh it's stopped" – then it starts up again.'***
> (Member of Family 09)

27 In New Zealand, a man may be forced from his home because noise from wind turbines will make his house 'uninhabitable'. After 20 years, it is understandable he is reluctant to leave. However, the nearest of the planned twelve turbines is only 500m from his boundary, and the decibel levels will exceed those allowable, according to the state-owned power company's representatives.

28 In 2005, a family living near the Te Apiti wind farm in New Zealand, had to move house because noise and vibration *'made it impossible for them to stay'*. [http://stuff.co.nz : *Turitea man fears he'll have to go.* 10 November 2006]

Indeed, those living near the Te Apiti wind turbines have first-hand experience with those problems:

> *'... in an easterly there is an intrusive rumble for days on end. They say the windmills emitted a low frequency noise for three days on end, making their lives a living hell.'*

At another time,

> *"... the rumbling was so bad it sounded like one of those street cleaning machines was driving up and down near the house. In fact it sounded like it was going to come through the house,"* said Wendy Brock.

29 According to Meridian, the developer:

> ***'... it's a small number of people making a big noise about nothing.'***

And another Meridian spokesperson, Alan Seay, said that:

> ***'... the monitoring has shown quite clearly they were well within the guidelines.'***
> [Flurry of complaints after wind change. TV1 News, New Zealand, 25 July 2005, http://tvnz.co.nz/view/page/411749/599657]

30 In Nova Scotia, Canada, one family and one wind farm developer have drawn different conclusions from similar noise readings at the family's home. Although the family insists that the noise from the 17 wind turbines – the closest is 400m from their home – has affected their well-being, the developer does not acknowledge any deleterious effects on the family. [Keller J. Nova Scotians flee home, blame vibrations from 17 turbines for loss of sleep, headaches. Canadian Press, 13 November 2006, http://thestar.com]

The d'Entremont family complained of noise and low frequency vibrations in their house after the wind turbines began operation in May 2005. The inaudible noise deprived his family of sleep, gave his children and wife headaches, and *'made it impossible for them to concentrate'*. They now live nearby; if they return to their home, the symptoms return.

31 *'But a study released this month by the federal natural resources department, which oversees funding for wind farm projects, found no problems with low-frequency noise, also known as infrasound.'*

The government report concludes that the measurements:

'indicate sound at infrasonic frequencies below typical thresholds of perception; infrasound is not an issue'.

The developer says he was not surprised by the report's findings:

'It essentially says that there's no issue whatsoever with infrasound.'

32 D'Etremont hired his own consultant to record the noise levels at his home:

'Gordon Whitehead, a retired audiologist with twenty years of experience at Dalhousie University in Halifax conducted tests.'

Whitehead's data was similar to that of the government's report. However, as a health professional, Whitehead reaches a different conclusion:

'They're viewing it from the standpoint of an engineer; I'm viewing it from the standpoint of an audiologist who works with ears ... The report should read that (the sound) is well below the auditory threshold for perception. ***In other words, it's quiet enough that people would not be able to hear it. But that doesn't mean that people would not be able to perceive it.'***

Whitehead explains that

'... low-frequency noise can affect the balance system of the ear, leading to a range of symptoms including nausea, dizziness and vision problems. It's not perceptible to the ear but it is perceptible. It's perceptible to people with very sensitive balance mechanisms and that's generally people who get very easily seasick.'

33 The developer has acknowledged that some questions remain:

'From our perspective, I think it's really up to the scientific community to really address and research such issues (as low-frequency noise) ... I know there is research that points to different directions.' [Keller J. Nova Scotians flee home, blame vibrations from 17 turbines for loss of sleep, headaches. Canadian Press, 13 November 2006, http://thestar.com]

34 In a newspaper article describing the d'Etremonts' situation and the wind power company's position, Michael Sharpe, a Dalhousie University audiologist, said that:

'Even if someone isn't affected directly by low-frequency noise, the constant swoosh of the blades, even at allowable levels, can have psychological effects.

"If the sound is audible and it annoys you, then it can seem louder," says Sharpe who compares it to a dripping tap that can keep someone awake at night.

"As your stress level increases, your awareness of the annoying sound increases as well. As we know, elevated stress levels for a prolonged period of time can have a negative health effect." ' [Keller J. Turbines stir up debate. *The Chronicle Herald*, Halifax, Nova Scotia 21 May 2006.]

35 The d'Etremonts are unable to sell their home because of the wind farm. [Keller J. Nova Scotians flee home, blame vibrations from 17 turbines for loss of sleep, headaches. *Canadian Press*, 13 November 2006 http://thestar.com]

36 Dr Robert Larivee, a Professor of Chemistry who lives 3000m east of twenty wind turbines – commissioned in 2003 – in Meyersdale, Somerset County, Pennsylvania, USA, wrote to his County Commissioners (2005) after an acoustician measured noise at his property that rose to 75 dB.

> *'These levels are much higher than those predicted by the company. There are a number of reasons that may contribute to this. Probably the most significant factor is the topology of the area. Our area has many mountains and valleys ...'*

Dr Larivee quotes the US Environmental Protection Agency, which says that

> *'noise levels above 45 dB(A) disturbs sleep and most people cannot sleep above the noise level of 70 dB(A). Emotional upset, irritability and other tensions, may also arise. Noise contributes to ailments like indigestion, ulcers, heartburn and gastrointestinal malfunction in the body.'* [Letter from Dr Robert Larivee, Meyersdale, Pennsylvania, USA, to the County Commissioners http://www.pbase.com/wp/image/39285457]

37 Another resident of Meyersdale, who lives less than one mile from the twenty wind turbines, wrote a lengthy letter on 7 March 2006 to 'Interested Parties'. Karen Ervin felt she had to *'share the realities and impacts'* of living near a wind turbine facility. She calls her situation the **"Human Experimental Factor"**, as the community deals with *'the multiple nuisances and issues'* affecting her family, her neighbours, and local adjacent property owners during the two years the wind turbines have been operating:

> *'Prior to the building of the facility, our neighbors and we were never made aware of the nuisances that occur with a wind turbine facility. The noises emitted from the turbines have definitely changed our style of living. The noises produced from the blades turning on the turbines create a 'threshing' sound within and around our home as well as the adjacent properties ...'*
>
> *'At times it is difficult to fall asleep with the "pounding" of the turbines. One is often awakened by the 'droning' noise of the turbines, finding it most difficult to fall back asleep. The noise becomes so disruptive; one can concentrate on nothing else but the constant droning. During the winter months, the noise is quite unbearable at times, sounding like drums beating constantly in the background. During the summer months, we cannot have our windows open ...'*
>
> *'Advocates for these facilities will often compare this "threshing" noise to the "peaceful" sound of waves beating against the rocks at the seashore; but I*

have been to the seashore and it certainly is in no way comparable to the "calming sound" of waves.'

Noise is not the only problem: flicker and 'strobing' are also nuisances. Ms Ervin concludes her letter with this observation:

'This industry without stringent regulations can be truly labelled a "Pandora's Box". Be careful for what is opened, and be prepared for the negative impacts that have occurred and continue to occur with this industry.' [Letter, Karen Ervin, Meyersdale, Pennsylvania, USA, 7 March 2006, www.pbase.com/wp/image/39285457]

38 Yet another resident living near the Meyersdale wind turbine facility, Mr Rodger Hutzell, Jr, and his family experienced

'... noise nuisance issues, specifically when trying to go to sleep at night. The noises are greater during the winter months. The noise appears to correlate to a continual droning sound. When awakened at night, there are times that is impossible [sic] to get back to sleep due to the threshing sounds produced by the wind turbines.' [Letter, Rodger A Hutzell, Jr, Meyersdale, Pennsylvania USA, 13 February 2005, www.pbase.com/wp/image/39285457]

39 In Mackinaw City, Michigan, USA, wind turbines rise 325 feet high, visible from nearby homes. Kelly Alexander's home is ¼ mile away from the nearest turbine. Initially Mr Alexander was in favour of the turbines, especially after the developer's assurances that the wind turbines would not be noisy. Flicker is also a problem, but this was never mentioned by the developer to Mr Alexander or the community.

Once the turbines became operational, Alexander heard

'a constant humming sound inside his home when the turbines are running, whether the windows are open or not. He said the situation was unliveable and all he wants is for things to be the way they were ...'

40 **The wind energy company representative said that it *'has lived up to ordinance requirements.'***

Alexander's response was:

'Stop lying about these turbines. Tell people the truth.' [Holland *Sentinel*, 31 December 2002]

41 In September 2002, the Mackinaw *Journal* reported on these turbines. Danny Dann and Kelly Alexander said that the turbines *'were exceeding a 60-decibel noise limit'*, and that ten other immediate neighbours were also concerned about the noise. The Mackinaw City Community Development Director said that they had sought legal advice because they did not have *'anything in our lease agreement to terminate the contract.'*

42 The owner, Bay Windpower, planned to erect at least two more wind turbines in the same area. [McManus S. Turbines still causing a problem, neighbors say. Mackinaw *Journal*, August 29 – September 26, 2002, p 3]

43 In 2004, Dr James LeFanu wrote that *'there have been some interesting comments on the substantial health problems – headaches, anxiety, sleep disturbances'* experienced by those living near wind farms:

> *'The cause seems to be the low-frequency noise generated by the incessant throb of their turbines ("like a concrete mixer in the sky"). "I like to think I know a bit about sound," writes Basil Tate, a recording engineer from Cornwall, "but it always amazes me how my wife can feel low-frequency sounds that are a long way away and be extremely distressed by them." Little wonder that some of those living close to wind farms have been forced to flee their homes.'* [LeFanu J, Dr. In sickness and in health. *Daily Telegraph* 14 March 2004]

44 Unhappily, this is not an exaggeration. Gwen Burkhardt was surprised when Dewi Jones, director of Windjen, which runs Blaen Bowi wind farm in Wales, UK, said:

> ***'There are a lot of wind farms operating in the UK and we haven't come across the complaint before.'*** ['Did turbines make you sick? Journal 18 May 2005, www.thisissouthwales.co.uk]

In her letter to the Journal [1 June 2005], Ms Burkhardt wrote that:

> *'I spoke to you and two of your employees on March 10 this year ... I explained to you in great detail about my own illness which was also brought on by the low frequency sound emitting from the very same turbines.*
>
> *It has caused me and my family a great deal of distress and has resulted in us having to move away from the area where I was born and where we have farmed for the last 27 years. Have you just forgotten our conversation? Do you simply not care? ... I do remember you sympathising with me and also telling me that you would not like to live near the turbines yourself.'* [Burkhardt G. Complaints are not new. *Journal*, 1 June 2005, www.thisissouthwales.co.uk]

45 In July 2005, Mr Murray Barber wrote to inform Energiekontor AG about the noise problems at the Forestmoor wind farm near Bradworthy, Devon, UK. His family's home, located 650m from the nearest of three turbines, is affected especially during calm days when the noise is very audible.

> *'The noise nuisance caused is irritating, distracting, stressful ... We do not understand why it is necessary for all three turbines to be driven at a high speed of rotation in absolute still air.'* [Letter from M Barber to Energiekontor AG, 12 July 2005]

In response, Energiekontor AG informed Mr Barber that:

> ***'The threshold of hearing is considerably lower than these levels, so noise from the turbines will be audible, however, at a level which is considered by the guidelines not to unduly affect amenity.'*** [Letter to M Barber from Energiekontor AG 19 July 2005]

46 In Fenner, New York, USA, when the trees are bare, Wayne Danley's wife 'flees' the living room of their house because of the flicker created by the turbine's rotating blades. Mr Danley lives 900 feet from the nearest wind turbine:

> *'It sounds like a train going through, except the train never comes through ... It's too close.'* [Neighbors complain of wind farm nuisances, The Albuquerque *Tribune*, 28 April 2006]

In response, Marion Trieste, publicist for the Alliance for Clean Energy New York, said:

> ***'There's a lot of misinformation, and a lot of inflamed discussion about negative encroachment.'*** (Neighbors complain of wind farm nuisances, The Albuquerque *Tribune* 28 April 2006)

And according to Laurie Jodziewicz, a policy specialist for the Alliance, **there are complaints about the** ***'strobe-light effects, but those occur only during certain months of the year and depend on the sun's angle to the turbine blades.'*** (Neighbors complain of wind farm nuisances, The Albuquerque *Tribune* 28 April 2006)

47 Given the sophistication of engineering design computer modelling, one might presume that these effects could be calculated prior to the construction of the wind turbines. However, Mr Danley had it right: the wind turbine was too close. With appropriate planning and distances between homes and wind turbines, these problems would not only be attenuated, they would cease to exist.

> *"It's not there all the time, but you're always waiting for it ... [It's] totally infuriating.'*

The thump-thump-thump 'reverberates up to 22 times a minute,' said Les Nichols, who lives beside a wind farm in Askam, Furness, UK. When seeking permission for the seven turbines, the developers *'guaranteed there would be no noise nuisance.'* (Garrett A. Ugly side of wind power. The Observer, Sunday, March 2, 2003)

48 Yet Bruce Allen, a director of Wind Prospect, the management company for the owner, PowerGen Renewables, said that:

> ***'The wind farm "had not breached its planning requirements. It's a subjective thing – like living beside a busy road."'*** (Garrett A. Ugly side of wind power. The Observer, Sunday, March 2, 2003)

Garrett's article continues:

> Giant wind turbines *'planted on your doorstep ... can transform a tranquil neighbourhood overnight into a menacing industrial site ... there are no rules about how close they can be to homes.'*
>
> *'The Welsh Affairs Select Committee recommended they shouldn't be less than 1.5 kilometres (0.93 miles) from any house, but developers generally go as close as between 500 metres (1,640 ft) and 600 metres (1,968 ft) ...'* (Garrett A. Ugly side of wind power. *The Observer*, Sunday, March 2, 2003)

49 As Phoebe Lockett, who lives near the Bears' Down wind farm in Cornwall, UK, wrote in a personal communication:

> *'There seems to be little known of what noise there may be from wind turbines and very few people who have genuine expertise in this area. The planning guidelines and studies carried out beforehand are, in my opinion, of little use.'*
>
> *'Please let me know if I can be of further assistance, as I do not like to think of others having to go through the same distress.'* [Letter, personal communication, 15 November 2003]

50 Eleven wind turbines, 121m high, have been operating in Taurbeg, Cork, Ireland, since February 2006, where residents *'are anything but happy ...'* The noise from the turbines are causing sleepless nights; one resident said the noise was like a *'plane which consistently hovers but never lands.'*

Another resident told the newspaper that *'The thought of another six going up within 500 metres of my front door is just a nightmare ... The noise from the windmills kept everybody in the area awake.'*

There were a number of complaints about the inaccuracies of the photomontages produced by the developer during the application process. Residents also suffer flicker, and one person labelled the result *'visual chaos'*.
[Herlihy M. Windmills 'are a nightmare'. The Corkman, 6 April 2006]

51 In the summer of 2006, eight wind turbines with an installed capacity of 16MW became operational at Deeping St Nicholas, Lincolnshire, UK. The noise from these turbines transformed the lives and the livelihood of the Davis family, living in a farmhouse only 907m from the nearest turbine. Jane and Julian Davis, who farm at Deeping St Nicholas and who learned of the development while reading their local newspaper, did not object to the development. They support wind energy and believe that renewable energy sources are essential to preserving the environment.

Although the Davis family cannot see the wind turbines from their home, the noise – both inside and outside their home, and which also caused vibrations within the structure of their home – has had a deleterious impact on their health and sense of well-being. Prior to the wind farm, they had no problems sleeping through the night. Now, when the wind blows from the southeast or the southwest, the noise from the acoustic radiation seriously disturbs their sleep.

> *'They have spent more than 60 nights in the last six months sleeping at friends' houses', and when home, they 'are existing on less than four hours sleep a night and sometimes a lot less.'* [Couple driven out of home by wind farm. Spalding Today (UK) 21 December 2006]

After taking its own acoustic readings, the local Council confirmed the noise problem, and it is investigating the matter further. [Davis J. Personal communication, 19 January 2007]

Local land agents have told them that their property is 'unsaleable'. Although consultants for the developer are evaluating the issue, and the Dti are investigating wind farm noise, that does not alleviate the impact on the family. [Tasker J. 'Wind farm noise is driving us out of our house.' Farmers Weekly 12 January 2007]

As the noise established itself as an ongoing problem, the Davis family learned that developers had used only predicted levels for their home without taking actual baseline measurements. Indeed, background noise most often measured below 20 dB at night (and usually in the range of 14 dB); now noise in the range of 40 dB occurs when the wind shifts to the southeast or the southwest, and on occasion, the noise has measured over 60 dB. [Personal Communication, 19 January 2007]

Quite generously under these circumstances, the Davis family continue to support wind energy but believe that wind turbines must be sited further from homes because the noise level and the impact of the noise cannot be accurately predicted. Jane Davis says that:

> *'More needs to be done if wind power is to become a viable alternative source of energy. It is a national issue and the Government ought to be doing more about this if we need lots more wind power.'* [Spalding Today (UK) 21 December 2006]

The Environmental Statement that accompanied the developer's application said that there would be no noise. [Davis J. Personal communication, 19 January 2007]

Meanwhile, Jane Davis says that she and her family are literally ***'fighting for our lives.'*** [Personal communication, 19 January 2007]

52 These are the voices and concerns of people who are despairing. However, with civic spirit, they speak out to alert others to the realities of living near wind turbines. As Bell noted in his 1966 report on noise for the World Health Organization:

> *'Anti-noise campaigns serve a useful purpose in focusing public attention on the matter; they provoke discussion and are often a stimulus to positive control measures.'*

53 According to Dr Dilys Davies, consultant clinical psychologist:

> *'Noise problems can lead to ill health'*, leaving the person *'more easily disturbed by noise in the future ... There is pressure on the heart, your breathing and whole arousal system. Your muscles tense as you wait for the noise, and if you are not careful you get used to being in that state constantly ...'* [Aitch, I. Keep It Down. Telegraph, 2 December 2006]

54 Many of those affected by wind turbine noise believe that the developers and decision-makers of the State have misled them. One explanation might be that the methodology for calculating the disturbance levels created by wind turbines at nearby homes is woefully inadequate, concentrating almost entirely on audible sound levels while dismissing other noise characters with a 'penalty in the

condition' [Planning Approval], which has produced unreliable information. The consequent release of noise pollution on people's homes produces sleep deprivation and other health injury, and the adverse effects are entirely avoidable.

There appears to be a total 'disconnect' between the experiences of those living near wind turbines and those who have a commercial interest.

55 The natural commercial instinct of developers is to maximise development potential from land, thereby leaving the minimum distance between turbines and homes. This presumes reliability and certainty in determining the physical impacts on families. However, such reliability and precision in calculating the effects does not exist, as the wind energy industry itself notes in its professional literature. (*See Section 4.0, Acoustics, of this paper.*)

56 It is too easy to dismiss the reports of noise disturbances and flicker effects by people living near turbines. Yet these problems emanate from many people in many countries, living in varied topographies, with one thing in common: they all live in close proximity to wind turbines.

57 It is somewhat hypocritical of public officials to decry the despoiling of the environment on a global basis, while ignoring the despoiling of the environment – including noise pollution – on a local level. At what point will officials and government agencies respond to these issues that involve the genuine – and avoidable – suffering of those living near wind farms? **At the least, further investigation into the health effects is warranted, with a minimum buffer zone of 2km between the nearest wind turbine and any dwelling.**

Section 4.0 ACOUSTICS

Acoustic Radiation experienced by people living near commercial wind turbines

1 In 2004, a small group met to consider the likely cause of adverse health effects reported by families where developers built wind turbines too close to their homes. Prof James Lovelock, retired NASA scientist and Harvard Medical School; Prof Ralph Katz, Chair, Department of Epidemiology and Health Promotion, New York University; Dr Amanda Harry, physician; and Dr David Coley, acoustician, Exeter University, decided the relationship was most likely to be an acoustic radiation of sound characters, which in combination unbalanced the natural function of the human body.

2 The reason for this is that the human ear responds not only to 'loudness', that is, sound pressure, measured in decibels – dB – with which many people are familiar, but also to sound frequency, measured in Hertz (Hz). [WHO Fact Sheet No 258, 2001]. In addition, sound affects the human body itself; even when a sound is 'inaudible' to the ear, the character of the sound may affect the body.

3 While the wind energy industry seeks to dismiss the adverse health effects reported by families living near wind turbines, there is ample evidence from medical research that noise in diverse circumstances can indeed have a negative impact on health. Noise can induce adverse physical and/or psychological symptoms. The qualities of the symptoms are similar to the complaints of those living near wind turbines. The phenomena may be produced intentionally, e.g., in a laboratory or in a specific instance, or unintentionally by the interaction of technical events, as with wind turbines.

4 Military weaponry exists that relies on low-frequency sound to disperse crowds or control crowd behaviour. [The Cutting Edge: Military Use of Sound, The Toronto Star (Canada), 6 June 2005] The effect of low-frequency noise at high intensities creates discrepancies in the brain, producing disorientation in the body:

> *'The knees buckle, the brain aches, the stomach turns. And suddenly, nobody feels like protesting anymore. The latest weapon in the Israeli army's high-tech tool kit.'*
>
> *'The intention is to disperse crowds with sound pulses that create nausea and dizziness. It has no adverse effects, unless someone is exposed to the sound for hours and hours.'* [The Toronto *Star*, 6 June 2005]

5 Hillel Pratt, a professor of neurobiology specializing in human auditory response at Israel's Technion Institute, said,

> *'It doesn't necessarily have to be a loud sound. The combination of low frequencies at high intensities, for example, can create discrepancies in the inputs to the brain.' Such technologies produce 'simulated sickness'.*
> [Pratt H. Personal communication, 14 March 2006]

In a subsequent communication, Prof Pratt explained that:

> *'... by stimulating the inner ear, which houses the auditory and vestibular (equilibrium) sensory organs with high intensity acoustic signals <u>that are</u>*

BELOW the audible frequencies (less than 20Hz), the vestibular organ can be stimulated and create a discrepancy between inputs from the visual system and somatosensory system (that report stability of the body relative to the surroundings) and the vestibular organ that will erroneously report acceleration (because of the low-frequency, inaudible sound). This will create a sensation similar to sea or motion sickness. Such cases have been reported, and a famous example is workers in a basement with a new air-conditioning system that all got sick because of inaudible low frequency noise from the new system.'
[Pratt H. Personal communication, 15 March 2006]

6 Wind turbines create these unintentional acoustic effects via the confluence of their design and operation. Noise, including low frequency noise, are long-standing issues with wind turbine design and operation. The wind turbine interacts with the topography, meteorology, spatial structure of the site, and with other wind turbines on the site. As an example of this unintentional confluence: Wind turbines produce visual flicker and strobe effects at certain times of the day, an effect similar to driving by a stand of trees when the sun is behind them. Acoustic characters and visual characters can combine and induce body 'disharmony'. Dr Bucha first identified this effect in the 1950s, after he was asked to investigate a series of unexplained helicopter crashes.

7 The pilots surviving the crashes reported feeling fine until the sudden onset of nausea and dizziness. During the episode, pilots lost control of their aircraft. Bucha found that when the blades maintained a rotational rate for sufficient time, the resulting strobe effect of sunlight closely matched human brainwave frequencies. The 'Bucha effect' is a seizure-inducing effect of light flashing in high frequency, similar to epilepsy but without being restricted to a small fraction of the population.

8 In "Present Status of Aeroelasticity of Wind Turbines", a report by Flemming Rasmussen and his colleagues at the Riso National Laboratory, Denmark, the authors observed:

> *"The term aeroelasticity is inherited from aeronautical engineering, and applying this with respect to wind turbines also makes an association to the high level of technology. From this perception the wind turbine is a helicopter. The operation of the flexible rotor in the turbulent atmospheric boundary layer is influenced by the control actions involves many of the same phenomena."* [Rasmussen F; Hartvig Hansen M; Thomsen K; Larsen TJ; Bertagnolio F; Johansen J; Aagaard Madsen H; Bak C; Melchior Hansen A. Present status of aeroelasticity of wind turbines. *Wind Energy* 2003; 6(3):213-228]

9 The military has made use of the combination of visual and acoustic characters to control behaviour. A report of the United States Air Force Institute for National Security Studies identifies and describes numerous non-lethal techniques. Among those that pertain to acoustic and/or optical effects on human physiology, several share characteristics with wind turbine noise and visual effects. [Bunker RJ, ed. Nonlethal Weapons. USAF Institute for National Security Studies, INSS Occasional Paper 15, July 1997].

'Acoustic infrasound: very low frequency sound which can travel long distances and easily penetrate most buildings and vehicles. Transmission of long wavelength sound creates biophysical effects, nausea, loss of bowels, disorientation, vomiting, potential organ damage or death may occur. Superior to ultrasound because it is 'inband', meaning it does not lose its properties when it changes mediums such as air to tissue. By 1972 an infrasound generator had been built in France, which generated waves at 7Hz. When activated it made the people in range sick for hours.'

Techniques include:

a. Bucha effect: high intensity strobe lights that flash at near human brain wave frequency causing vertigo, disorientation and vomiting.

b. Stroboscopic device: devices employed against demonstrators that use stroboscopic flashing; same principle as a discotheque strobe. In the 5 – 15Hz range, these devices can cause various physical symptoms and in a small portion of the population may trigger epileptic seizures.

c. Lag time: The physiological time lag that occurs between the time a stimulus is perceived until the body responds. In a healthy, well-rested human, this takes about three-quarters of a second.

d. Sensory overload: A temporary inability of an organism to correctly interpret and appropriately respond to stimuli because of the volume of the input.

10. Although the military examples use acoustic and visual devices that intensify physiological reactions, the noise and visual effects of wind turbines produce similar physiological reactions. Indeed, the physical complaints of those living near wind turbines share symptoms, though fortunately, not at the levels induced by the military devices. Unfortunately, those individuals living near wind turbines experience the adverse effects without remission. Additionally, military use relies upon high dosage over a short time span. Unintentional occurrence, as with wind turbines, produces a small dose over a long time-span with apparent compounding similar effects.

11. Another example of military use of LFN is called SONAR (SO(und) NA(vigation and R(anging). In *"Navy adapts sonar to protect whales"*, The Sunday Times reported on 26 March 2006, that amid evidence that navy sonar was causing whale and dolphin deaths by confusing them so that they would surface too quickly *'that they suffer fatal attacks of the 'bends'*:

'Navy warships are to be equipped with a £2.5m scanning system to spot marine mammals after post-mortem tests linked the death of beached whales to military sonar.

The use of military sonar appears to interfere with the echo-location system the animals use to navigate, leaving them so disorientated they misjudge depths and swim to the surface too quickly.

The low frequency system will operate at long range and the MOD admits it has the potential to be harmful to marine life. Liz Sandeman, co-founder of

Marine Connection, a conservation group, said, "Low frequency sonar can travel for hundreds of miles, yet the marine animal detection system will only work for two miles".'

12. Following the publication 'Noise annoyance from wind turbines – a review' [Pedersen E, August 2003], Pedersen et al published an article in August 2004, 'Living close to wind turbines – a qualitative approach to a deeper understanding'. [Pedersen E; Persson Waye K; Hallberg LRM. Proceedings of InterNoise2004, Prague, 2004]

    The authors state that:

    a. *'Informants annoyed by wind turbine noise perceived the impact of turbines as a serious intrusion of their privacy. The force of the violation experienced was partly determined by the informants' conception of the living environment as a place where audible and visual impact from wind turbines did not belong. Categories increasing or decreasing the intrusion were experiences of not being believed, being subjected to injustice, lacking influence, and being out of control.'*

    b. *'Surprisingly many respondents reported themselves as annoyed by wind turbine noise at rather low A-weighted sound pressure levels (dB), compared to other sources of community noise such as traffic noise ... One hypothesis is that wind turbine sound has special characteristics such as amplitude modulations that are easily perceived and that could lead to annoyance even at low sound pressure levels (dB). Furthermore, in earlier laboratory studies where noise from different wind turbines were compared, the most annoying noises were predominantly described by the subjects as "swishing", "lapping", and "whistling".'* [Persson Waye K and Ohrstrom E. Psycho-acoustic characters of relevance for annoyance of wind turbine noise. Journal of sound and vibration 2002; 250(1): 65-73]

    c. *'An interesting observation was that other responses due to wind turbines, such as annoyance of shadows from rotor blades, seemed to interact with the noise dose-response relationship indicating that exposure to noise from wind turbines should be studied within its context'.* [Pedersen E and Persson Waye K. Audio-visual reactions to wind turbines. Proceedings of Euronoise 2003; 5th European Conference on Noise Control, May 19-21, 2003, Naples, Italy, 2003]

    d. In describing the results of interviews with the study group living close to wind turbines, the report says that:

        'For some informants, the exposure reached further, not only intruding their home environment but also into themselves, creating a feeling of violation of them as a person. They expressed anger, uneasiness, and tiredness, disclosing being under strain, using a tense voice and sometimes crying when talking about the impact of the wind turbines.

        To be affected by the turbines to such a high degree, not being able to protect oneself from the intrusion that constantly raised negative emotions was experienced as a serious decline in well-being and life quality.'

13. In their article, 'Aeroacoustics of large wind turbines', Hubbard and Shepherd observe that buildings are affected by noise transmitted by wind turbines:

> *'The transmitted noise is affected by the mass and stiffness characteristics of the structure and its dynamic responses and the dimensions and layouts of the rooms. Minimum noise reductions occur at frequencies near 10Hz, probably because of associated major house structural resonances. This frequency range of low noise reductions unfortunately coincides generally with the frequency range of the intense rotational harmonics.* ***Noises in this low-frequency range will probably not be heard by human observers but may be observed indirectly as a result of noise induced vibrations of the building structure or furnishings.'***
> [Hubbard HH; Shepherd KP. Aeroacoustics of large wind turbines. JASA Journal of the acoustical society of America 1991 June; 89(6): 2496 – 2508, p 2505]

14. In 'Noise induced house vibrations and human perception', Hubbard's research indicates that:

   a. ***'A person inside the house can sense the impingement of noise on the external surfaces of the house by means of the following phenomena: noise transmitted through the structure …*** *vibrations of the primary components of the building such as the floors, walls and windows; the rattling of objects …'*

   b. Addressing the issue of 'whole body perception', Hubbard refers to the ISO Guidelines and says that a noise level outside a building between 55 – 60 dB (around 0.001 rms) in a frequency range of 0.1 HZ – 80 Hz, is the *'Most sensitive threshold of perception of vibratory motion by humans'.*
   [Hubbard HH. Noise induced house vibrations and human perception. Noise control engineering 1982; 19(2): 49 – 55]

15. In 'Do wind turbines produce significant low frequency sound levels?' [2004], GP van den Berg, observes that:

> *'Windows are usually the most sensitive elements as they move relatively easy because of the low mass per area. Perceptible vibrations of windows may occur at frequencies from 1 Hz to 10 Hz when the incoming 1/3 octave band sound pressure level is at least approaching 52 dB; at higher or lower frequencies a higher level is needed to produce perceptible vibrations. As can be seen in figures 1 –3 sound pressure levels above 60 dB at frequencies below 10 Hz occur close to a* ***turbine as well as 750 m distance and further.'*** [van den Berg GP. Do wind turbines produce significant low frequency sound levels? 11th International Meeting on Low Frequency Noise and Vibration and its Control, Maastricht, The Netherlands, 30 August – 1 September 2004. See also Stephens DG; Shepherd KP; Hubbard HH; Grosveld F. Guide to the evaluation of human exposure to noise from large wind turbines. NASA National Aeronautics and Space Administration, Langley Research Center, Hampton, Virginia (USA), NASA-TM-83288, March 1, 1982.] [emphasis added]

16. In 2003, the new International Standard for 'Equal Loudness Level Contours' was agreed (ISO 226:2003). In a comparative study with previous curves, Advanced Industrial Science and Technology (AIST) observed:

> *'Between the new and the previous standards, very large differences are recognised up to about 15dB (decibels) for a wide area of frequency region lower than 1KHz (1,000Hz).*
>
> ***A difference of 10dB means a 10 fold difference in sound energy and that of 15dB corresponds to a 30 fold difference (fig 1).'***

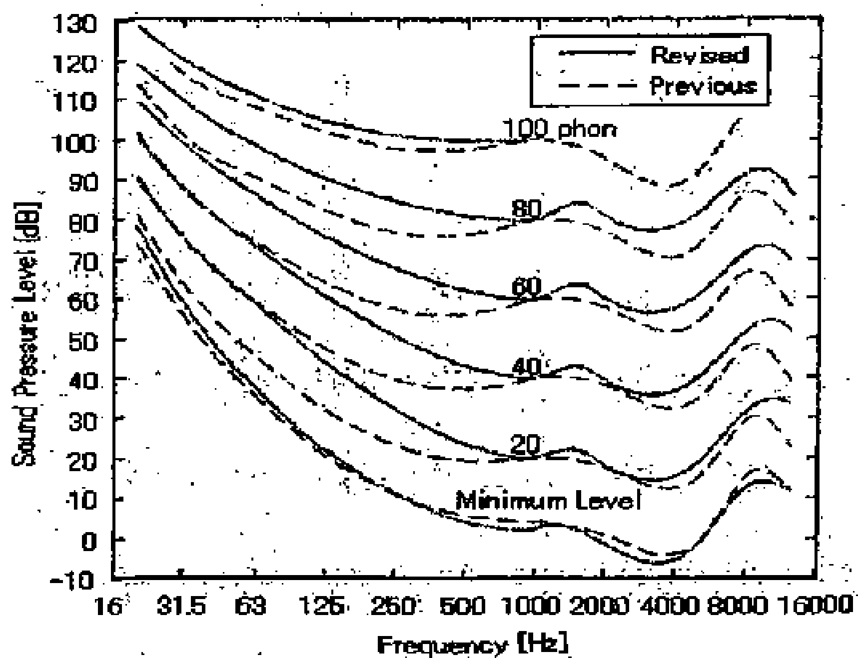


Fig. 1: Comparison between the new and the previous characteristics of equal-loudness-level contours. Remarkable differences are observed in the low frequency range.

Source: AIST. Full revision of International Standards for Equal-Loudness Level Contours (ISO 226), 2003 http://www.aist.go.jp

[Note: The threshold of hearing at about 20 Hz is circa 75dB.]

17. In a report by Dr D Manley and Dr P Styles, "Infrasound Generated by Large Sources", the authors discussed a test conducted near a wind farm in October 1994, using only vibration analysis equipment. Measurements were taken between 0.75 miles and 2 miles downwind of the wind farm at the same elevation:

> *'Wind speed was about 20 knots, and it was possible to hear turbines with a characteristic 'beat' (at about 0.8Hz) ...*
>
> *The blade rotation was usually timed at 43 rpm and therefore the main seismic wave is related to the rotational period of the three bladed machine.*
>
> *All three transducers show (from a typical frequency spectra) that there are odd numbered harmonics of the fundamental blade rotation frequency (0.8Hz, 2.4Hz and 4.0Hz being examples).*

In March 1995 experiments were repeated in eight places, in a location 0.75 miles UPWIND of the wind farm, with a 20 knot wind. The speed of turbine blades was visually measured at 43 rpm. The results clearly show a second harmonic (a higher harmonic) spaced 2.15 Hz ...
[Manley DMJP; Styles P. Infrasound generated by large sources. Proceedings of the Institute of Acoustics 1995; 17:239 – 246]

18. Wind turbines radiate noise not only above ground; they also radiate noise below ground. Following his investigations of ground vibration at the Eskdalemuir seismic monitoring facility in Scotland, Professor Peter Styles, in a summary report to the Defence Estate, made these recommendations:

    a. *To 'define an exclusion zone of 10 km within which no windfarm / turbine development is acceptable.'*

    b. *'Between 10 and 50 km the TOTAL permitted windfarm / turbine generated seismic rms amplitude should not exceed 0.25 rms measured at Eskdalemuir' [the recipient].*

    c. *'This is best illustrated with two hypothetical examples:*

        i. *'A single windfarm of 3 (no.) x 1.8 MW turbines located at 15 km from Eskdalemuir will produce a predicted rms amplitude of 0.20 nm.'*

        ii *'A single windfarm of 17 (no.) x 2.5 MW turbines located at 26 km from Eskdalemuir will produce a predicted rms amplitude of 0.11 nm.'*
        [Styles (Keele University). Summary Report to Defence Estates, 3 March 2004]

    d. *'We have clearly shown that wind turbines generate low frequency sound (infrasound) and acoustic signals which can be detected at considerable distances (many kilometres) from wind farms on infrasound detectors and low frequency microphones.'*
    [Styles P; Stimpson I; Toon S; England R; Wright M. Microseismic and infrasound monitoring of low frequency noise and vibrations from windfarms: recommendations on the siting of windfarms in the vicinity of Eskdalemuir, Scotland. Keele University (UK), Report for the Ministry of Defence, 18 July 2005]

19. The July 2005 Report by Prof P Styles, et al, "Microseismic and Infrasound Monitoring of Low Frequency Noise and Vibrations from Windfarms" commented:

    "When the windfarm starts to generate at low wind speeds, considerable infrasound signals can be detected at all stations out to c 10km. Clear harmonic components which are the second multiple and up of 1.4Hz (the blade passing frequency) can be seen although interestingly and somewhat enigmatically the blade passing frequency itself is not so strongly detected". [p 66]

    "We have clearly shown that both fixed speed and variable speed wind turbines generate low frequency vibrations which are multiples of blade passing frequencies and which can be detected on seismometers buried in the ground at significant distances away from the wind farms even in the

presence of significant levels of background seismic noise (many kilometres)." [p 76]

In answer to the question: *"If we have a wind farm of N turbines, how does the seismic amplitude increase as compared to 1 turbine?"*
Answer: *"We have shown it varies as the square root of N and this is to be expected because the turbines are not all in phase and neither are they operating at exactly the same frequency because of the slight possible variations in rotation speed and also wind conditions across the farm. There is also a possible 10% variation in speed (Optislip) which will cause broadening of the spectral peaks . They are quasi-random sources and therefore add as square root of N. Therefore 100 turbines are 10 times as noisy as one, not 100 times."* [p 77]
[Styles P; Stimpson I; Toon S; England R; Wright M. Microseismic and infrasound monitoring of low frequency noise and vibrations from windfarms: recommendations on the siting of windfarms in the vicinity of Eskdalemuir, Scotland. Keele University (UK), Report for the Ministry of Defence, 18 July 2005]

'*The Effect of Windmill Farms on Military Readiness*', a 2006 report by the US Department of Defense for the US Congressional Committees, supports Styles et al for the seismographic methods and devices used to measure low frequency noise and vibration at Eskdalemuir.

However, the Department of Defense report recommends that the United States modify the approach:

- *'Measurements of seismic noise generated by wind turbines that Styles made must be updated to reflect the increased size of SOA wind turbines.'* (SOA = State Of the Art) [United States Department of Defense. The effect of windmill farms on military readiness. Report to the Congressional Defense Committees. Office of the Director of Defense Research and Engineering, US Department of Defense, 2006, p 62]

20. Moreover, Hubbard and Shepherd ('Aeroacoustics of large wind turbines', 1991) observe in their discussion on Atmospheric Propagation,

'Acoustic refraction that arises from sound-speed gradients associated with atmospheric wind and temperature gradients, can cause non-uniform propagation around a sound source.'

In an *'illustration of the effects of atmospheric refraction, or bending of sound rays, caused by vertical wind sheer gradient over flat homogeneous ground for an elevated point source'*, the rays are bent toward the ground in a downwind direction. That is, the ground can act as a large and effective microphone at low frequencies.

21. The WHO *Guidelines for Community Noise 1999* (S.4.2.1) say that:

"Reverberation times below 1 s are necessary for good speech intelligibility in smaller rooms; and even in a quiet environment a reverberation time below 0.6 s is desirable for adequate speech intelligibility for sensitive groups."
[Authors' note: See also Section 3.51 of this Review]

22. Research by GP van den Berg, of the University of Groningen in the Netherlands, examines how wind turbine sound acts in the environment. In 'The Beat is Getting Stronger: The Effect of Atmospheric Stability on Low Frequency Modulated Sound of Wind Turbines' [*Journal of Low Frequency Noise, Vibration, and Active Control* 24(1), March 2005], van den Berg writes:

a. *'Our experience* ***at distances of approximately 700 m to 1500 m from the Rhede Wind Farm****, with the turbines rotating at high speed in a clear night and pronounced beating audible, is that the sound resembles distant pile driving. When asked to describe the sound of the turbines in this wind farm, a resident compares it to the surf on a rocky coast. Another resident near a set of smaller wind turbines, likens the sound to that of a racing rowing boat (where rowers simultaneously draw, also creating a periodic swish). Several residents near single wind turbines remark that the sound often changes to clapping, thumping or beating when night falls, like a washing machine.'* (p.14)

b. *'Part of the relatively high annoyance level and the characterisation of wind turbine sound as lapping, swishing, clapping or beating may be explained by the increased fluctuations of the sound [2.21]. Our results in table 2 show that in a stable atmosphere measured fluctuation levels are 4 to 6 dB for single turbines, and in long term measurements (over many 5 minute periods) near the Rhede Wind Farm fluctuation levels of approximately 5 dB are common but may reach values up to 9 dB.'* (p.14)

c. *'It can be concluded that, in a stable atmosphere, the fluctuations in modern wind turbine sound can be readily perceived. However, as yet it is not clear how this relates to possible annoyance. It can however be likened to the rhythmic beat of music: pleasant when the music is appreciated, but distinctly intrusive when the music is unwanted.'* (p.15).

d. *'The hypothesis that these fluctuations are important, is supported by descriptions of the character of wind turbine sounds as 'lapping', 'swishing', 'clapping', 'beating', or 'like the surf'.'*

e. *'Those who visit a wind turbine in daytime will usually not hear this and probably not realise that the sound can be rather different in conditions that do not occur in daytime. This may add to the frustration of residents'.* [See also Persson Waye et al, "Living close to wind turbines – a qualitative approach to a deeper understanding"] (p.15)

f. *'Fluctuations with peak levels of 3 – 9 dB above a constant level may have effects on sleep quality.* ***The Dutch Health Council ['Effects of Noise on Sleep and Health', pub. No. 2004/14] states that 'at a given L night value, the most unfavourable situation in terms of a particular direct biological effect of night-time noise is not, as might be supposed, one characterised by a few loud noise events per night. Rather, the worst scenario involves a number of noise events all of which are roughly 5 dB (A) above the threshold for the effect in question'.*** [emphasis added]

g. *'For transportation noise (road, rail, air traffic) the threshold for motility (movement), a direct biological effect having a negative impact on sleep quality, is a sound exposure level per sound event of SEL=40 dB (A) in the* *bedroom [Dutch Health Council]. The pulses in figure 6 have SEL-values up to 50 dB (A), but were measured on the façade. With an open window facing the wind turbines indoors SEL-values may exceed the threshold level.'* (p15)

23. GP van den Berg concludes:

    a. *'Atmospheric stability has a significant effect on wind turbine sound, especially for modern tall turbines.'* (p 15)

    b. *'First, it is related to a change in wind profile causing strong, higher altitude winds, while at the same time wind close to the ground may become relatively weak. High sound immission levels may thus occur at low ambient sound levels, a fact that has not been recognised in noise assessments where a neutral or unstable atmosphere is usually implied. As a result, wind turbine sound that is masked by ambient wind-related sound in daytime, may not be masked at night time.* [van den Berg GP. Effects of the wind profile at night on wind turbine sound. Journal of sound and vibration 2004; 277 (4-5): 955 – 970]

    c. *Secondly, the change in wind profile causes a change in angle of attack on the turbine blades. This increases the thickness (infra) sound level as well as the level of trailing edge (TE) sound.*

       'The calculated rise in sound level during swish then increases from 1 – 2 dB to 4 – 6 dB. This value is confirmed by measurements at single turbines in the Rhede Wind Farm where maximum sound levels rise 4 to 6 dB above minimum sound levels within short periods of time.' (p 15 – 16)

    d. Third, van den Berg notes that *'atmospheric stability involves a decrease in large scale turbulence ... As a result turbines in the farm are exposed to a more constant wind and rotate at a more similar speed with less fluctuations. Because of the near-synchronicity, blade swishes may arrive simultaneously for a period of time and increase swish level.*

       Sound level differences ($L_{A\,max} - L_{A\,min}$) (corresponding to swish pulse heights) within 5 minute periods over long measurement periods near the Rhede Wind Farm show that level changes of approximately 5 dB occur for an appreciable amount of the time and may less often be as high as 8 to 9 dB. This level difference did not decrease with distance, but even increased 1dB when distance to the wind farm rose from 400 m to 1,500 m. The added 3 – 5 dB, relative to a single turbine, is in agreement with simultaneously arriving pulses from two or three approximately equally loud turbines.' (p.16)

24. In 2001, Casella Stanger produced "Low frequency Noise", a report for DEFRA (Technical Research Support for Defra Noise programme). Section 4 addresses the 'Possible Effects of LFN':

    'As with any noise, reported effects include annoyance, stress, irritation, unease, fatigue, headache, possible nausea and disturbed sleep.

Low frequency noise is sometimes confused with vibration. This is mainly due to the fact that certain parts of the human body can resonate at various frequencies. For example the chest wall can resonate at frequencies of about 50 to 100Hz and the head at 20 to 30Hz.' [S.4.1]

25. In England, U.K., decision-makers are guided by the State according to Planning Policy Statement 22 (2004).

    PPS 22 'Noise' states:

    *"The 1997 report by ETSU-R-97 for the Dti **should** be used to assess and rate noise from wind energy developments."* [emphasis added]

    (Note: "should" is not a command statement.)

26. There were 14 Members of the ETSU-R-97 Noise Working Group (NWG), including the Chairman from the Dti. Nearly 60% were either from Power companies involved in wind farm schemes, wind energy trade associations, or specialist advisors to wind farm developers. [Preface, p. i]

    Indeed, the following statement appears in the introduction to ETSU-R-97:
    "While the Dti facilitated the establishment of this Noise Working Group this report is not a report of Government and should not be thought of in any way as replacing the advice contained with relevant Government guidance." [Preface p.i]

27. ETSU-R-97 states in its Executive Summary that:
    a. *"This document describes a framework for the measurement of wind farm noise and gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, **without placing unreasonable restrictions on wind farm development** or adding unduly to the costs and administration burdens on wind farm developers or local authorities."* [emphasis added] [Summary S. 1]

    b. *"The NWG ... wind farms are usually sited in the more rural areas of the UK where enjoyment of the external environment can be as important as the environment within the home."* (Summary S. 3)

    c. *" The NWG considers that absolute noise limits applied at all wind speeds are not suited to wind farms in typical UK locations and that limits set relative to the background noise are more appropriate in the majority of cases."* [Summary, S.8]

    d. *"The **recommendation** of the NWG is that, generally the noise limits should be set relative to the existing background noise at nearest noise-sensitive properties ... We have considered whether the low noise limits which this could imply in particularly quiet areas are appropriate and have concluded that it is not necessary to use a margin above background approach in such low-noise environments. **This would be unduly restrictive on developments** ..."* (emphasis added) [Summary S.11]

    e. *Separate noise limits should apply for day-time and for night-time. The reason for this is that during the night the protection of external amenity* *becomes less important* ***and emphasis should be on preventing sleep disturbance.*** *Day-time noise limits will be derived from background noise data taken during quiet periods of the day and similarly the night-time limits will be derived from background noise data during the night"* (night-time is defined as 11pm-7pm)

f. *"The NWG recommends that the fixed limit for night-time is 43 dB(A). This is derived from the 35 dB(A) sleep disturbance criteria referred to in PPG24. An allowance of 10 dB(A) has been made for attenuation through an open window (free-field to internal) and 2dB subtracted to account for the use of LA90.10min rather than LAeq.10min."* [Summary S.23]

g. *"Lower limit"*
Applying the margin above background approach to some of the very quiet areas in the UK would imply setting noise limits down to say 25 – 30 dB(A) based upon background levels perhaps as low as 20 – 25 dB(A). ***Limits of this level would prove very restrictive on the development of wind energy.*** *As demonstrated below, it is not necessary to restrict wind turbine noise below certain lower fixed limits in order to provide reasonable degree of protection of the amenity."* (emphasis added)

28. In contrast, two years after ETSU-R-97, the WHO *Guidelines for Community Noise 1999* set tighter maximum permitted levels for community noise, yet ETSU-R-97, page 20 refers to *"the WHO document Environmental Health Criteria 12 – WHO 1980(14).* Clearly, ETSU-R-97 does not reflect the latest World Health Organisation *Guidelines for Community Noise.*

29. Independent experts researched and wrote the WHO Guidelines for Community Noise 1999. In brief, the Guidelines state:

"In these Guidelines for Community noise only guideline values are presented. These are essentially values for the onset of health effects from noise exposure." (5th paragraph S. 4.1)

"For each environment and situation, the guideline values take into consideration the identified health effects and are set, based on the lower levels of noise that effect health (critical health effects). (6th paragraph S. 4.1)

"In dwellings the critical effects of noise are on sleep, annoyance and speech interference. To avoid sleep disturbance, indoor guideline values for bedrooms are 30 dB LAeq for continuous noise and 45dB LAmax for single sound events. Lower levels may be annoying, depending on the nature of the noise source...." (S 4.3.1 & see also S 3.3 sleep disturbance)

"Thus when assessing the effects of environmental noise on its people it is relevant to consider the importance of the background noise level, the number of events, and noise exposure level independently." (3rd paragraph S 4.1)

"Most problems occur at lower frequencies, where most environmental noise sources produce relatively high sound pressure levels." (S 2.6)

"If noise includes a large proportion of low-frequency components, values even lower than the guideline values will be needed, because low-frequency components in noise may increase the adverse effects considerably." (S 4.3)

"More regular variations of sound pressure levels with time have been found to increase the annoying aspects of the noise. For example, noises that vary periodically to create a throbbing or pulsating sensation can be more disturbing than continuous noise. (Bradley 1994b). Research suggests that variations at about 4 per second are more disturbing (Zwicker 1989)." (3rd paragraph S 2.3.2)

"At night sound pressure levels at the outside facade of the living spaces should not exceed 45 dB LAeq and 60 dB LAmax, so that people may sleep with bedroom windows open. These values have been obtained by ***assuming*** *that the noise reduction from outside to inside with the window partly open is 15 dB."*

30. It may seem that 15dB is a high level of attenuation through the external envelope especially for timber-framed buildings and high glazed areas. However, the guideline for the onset of sleep deprivation is 30dB, reduced if low frequency noise characters are present and further reduced if throbbing/pulsating characters are present – both of which are present for wind turbine noise. This lower figure represents a new base level to which is added the noise attenuation factor for the external envelope, with a window partially open, to give the outside façade level.

    [Note: the 30dB max for a bedroom is a continuous maximum noise level, which is substantially different to the ETSU-R-97 guideline that allows 5dB above background noise.]

31. The importance of an 'in the bedroom at night maximum level' is emphasised by the findings of GP van den Berg. Van den Berg's research reveals that [van den Berg GP. *Effects of the wind profile at night on wind turbine sound.* Journal of sound and vibration 2004; 277(4-5): 955-970]:

    'Since the start of the operation of a 30 MW, 17 turbine wind park, residents living 500 m and more from the park have reacted strongly to the noise; residents up to 1900 m distance expressed annoyance. To assess actual sound immission, long term measurements (a total of over 400 night hours in 4 months) have been performed at 400 and 1500 m from the park. In the original sound assessment a fixed relation between wind speed at reference height (10 m) and hub height (98 m) had been used. ***However, measurements show that the wind speed at hub height at night is up to 2.6 times higher than expected, causing a higher rotational speed of the wind turbines and consequentially up to 15 dB higher sound levels, relative to the same reference speed in daytime.*** *Moreover, especially at high rotational speeds the turbines produce a 'thumping', impulsive sound, increasing annoyance further. It is concluded that prediction of noise immission at night from (tall) wind turbines is underestimated when measurement data are used (implicitly) assuming a wind profile valid in daytime.'*

32. During stormy weather, the background wind noise sometimes disturbs sleep, but to suffer wind turbine noise in addition (as per ETSU-R-97) is likely to make sleep intermittent if not impossible.

'Many acoustical environments consist of sounds from more than one source. For these environments, ***health effects are associated with the total noise exposure****, rather than with the noise from a single source (WHO 1980b.)"* [WHO Guidelines for Community Noise 1999, S.3.8, The effects of combined noise sources]

33. In assessing how a level of below 30 dB is achieved (WHO S. 4.3.1 & S. 3.3), allowance must be made for a window to be open in order to provide ventilation, especially in warm weather. In addition, the sound reduction index of the external wall is only part of the consideration. The construction of the ceiling might only be a 15mm sheet of plaster, some thermal insulation (not sound insulation), a paper-thin vapour barrier, and thin roofing slate. The transmission loss through the ceiling or roof is slight.

'The evidence on low-frequency noise is sufficiently strong to warrant immediate concern. Various industrial sources emit continuous low-frequency noise (compressors, pumps, diesel engines, fans, public works); and large aircraft, heavy duty vehicles and railway traffic produce intermittent low-frequency noise. Low-frequency noise may also produce vibrations and rattles as secondary effects. Health effects due to low-frequency components in noise are estimated to be more severe than for community noises in general (Berglund et al. 1996).'

'Since A-weighting underestimates the sound pressure level of noise with low-frequency components, a better assessment of health effects would be to use C-weighting.' [WHO Guidelines for Community Noise 1999, S.3.9, 'The effects of combined noise sources'.]

'To protect the majority of people from being seriously annoyed during the daytime, the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55 dB LA_{eq} for a steady, continuous noise. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound pressure level should not exceed 50 dB LA_{eq}. These values are based on annoyance studies, ***but most countries in Europe have adopted 40dB LA_{eq} as the maximum allowable level for new developments (Gottlob 1995). Indeed the lower level should be considered the maximum allowable sound pressure level for all new developments whenever feasible.****'* (WHO S.4.3.1.)

34. It should be noted that:

   a The 30 dB LAeq is not variable with external weather conditions – it is a fixed level regardless of external weather conditions and external background noise.

   b The nature of the pulsating beat of the wind turbine, together with probable ground vibration, and the low frequency noise character, are clear reasons to support a lower level than 30 dB LAeq, especially at night.

   c WHO *Guidelines for Community Noise 1999* does not provide for measurements limited to background noise plus 5 dB as per ETSU-R-97, but clearly states that noise in a bedroom above 30 dB causes sleep disturbance.

d It is possible to conceive of a position where a lightly constructed dwelling with minimal sound transmission loss between bedroom ceiling and the external wall is subjected to an external wall sound of 45 dBA at night. If the WHO 30dBA maximum bedroom level is applied but reduced to reflect the pulsating character and the low frequency character, the actual measurement inside the bedroom, with the window open for ventilation, will be only marginally less than 45 d BA, potentially creating a 15 dBA excess of sound **which is a staggering 30 fold difference in sound energy.** (See S. 4.18 & S. 4.40 of this review.)

35. The WHO Guidelines for Community Noise 1999 are shown on the following chart:

Table 1: Guideline values for community noise in specific environments: WHO *Guidelines for Community Noise 1999*

Specific Environment	Critical Health Effects	LAeq [dB(A)]	Time Base [hours]	LAmax fast [dB]
Outdoor living area	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening	55 50	16 16	- -
Dwelling, indoors Inside bedrooms	Speech intelligibility & moderate annoyance, daytime & evening Sleep disturbance, night-time	35 30	16 8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School classrooms & pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	during class	-
Pre-school bedrooms, indoor	Sleep disturbance	30	sleeping-time	45
School, playground outdoor	Annoyance (external source)	55	during play	-
Hospital, ward rooms, indoors	Sleep disturbance, night-time Sleep disturbance, daytime and evenings	30 30	8 16	40 -
Hospitals, treatment rooms, indoors	Interference with rest and recovery	as low as possible		

The WHO *Guidelines for Community Noise 1999* also examine the acoustic measurement of sound:

'The A – weighting (dBA) is most commonly used and is intended to approximate the frequency response to our hearing system ... C – weighting (dBC) is also quite common and is nearly a flat frequency response with the extreme high and low frequencies attenuated. When no frequency analysis is possible, the difference between A weighted and C weighted levels gives an indication of the amount of low frequency content in measured noise.' (WHO S.2.1.2)

'Noise measures based solely on LAeq values do not adequately characterize most noise environments and do not adequately assess the health impacts of noise on human well-being. It is also important to measure the maximum noise level and the number of noise events when deriving guideline values. ***If the noise includes a large proportion of low-frequency components, values even lower than the guideline values will be needed, because low-frequency components in noise may increase the adverse effects considerably.*** *When prominent low-frequency components are present, measures based on A-weighting are inappropriate. However, the difference between dBC (of dBlin) and dBA will give crude information about the presence of low-frequency components in noise. If the difference is more than 10 dB, it is recommended that a frequency analysis of the noise be performed.'* (WHO S.4.3)

36. In August 2006, the Dti (UK) published 'The Measurement of Low Frequency Noise at Three UK Wind Farms' [Report for Dti by Hayes McKenzie Partnership Ltd].The report measured LFN at three wind farm sites in the UK, and although unidentified in the report, these sites are believed to be:

    Site 1: Askam, Cumbria 7 x 0.66 MW wind turbines of 4.62 MW installed capacity, built 1999.

    Site 2: Bears Down, Cornwall 16 x 0.6 MW of 9.62 MW installed capacity, built September 2001.

    Site 3: Blaen Bowi, Carmarthenshire 3 x 1.3 MW of 3.9 MW installed capacity, built July 2002.

37. For the purpose of its Report, the Dti defined low frequency noise sources as between 20 – 250 Hz [S.1.3]. The Dti stated: *'Infrasound is noise at frequencies below the normal range of human hearing, i.e., less than 20 Hz.'* [S.1.2] The report stated that *'noise sources associated with these frequencies are generated by unsteady loading of the wind turbine blade.'*

    Hubbard and Shepherd also make this observation. Their paper, 'Wind turbine acoustics' [NASA Technical Paper 3057, 1990, p 2496], considered three upwind and four downwind turbines. The upwind MODS.B and WWG-0600 machines measured between 60 dB – 70 dB below 20 Hz [p 2499; p 2502].

38. The Dti Report supports the Hubbard and Shepherd measurement of upwind machines:

'Measurements of infrasound [below 20 Hz] in the vicinity of wind farms, and confirmed within this study, indicate typical sound pressure levels between 1 – 10 Hz of 60 – 80 dB, which falls well below the normal environmental infrasound levels experienced by all humans.' [p 12]

39. The Dti Report observes:

'The common cause of complaints associated with wind turbine noise at all three wind farms is not associated with low frequency noise, but is the audible modulation of the aerodynamic noise, especially at night.' [p 3]

In the Report, the Dti does not provide evidence to support this statement as the sole cause of complaints. There is little doubt that audible modulation is a contributory cause, but as Professor James Lovelock, Professor Ralph Katz, Dr Amanda Harry, and Dr David Coley suggested, the "common cause" will be the acoustic radiation of sound characters of which a cocktail strikes the human body, the responses mainly being of a physiological (biologic/medical) nature, producing both short-term and long-term effects.

40. Section 2.10 of this Review noted several examples of public health concerns that emerged only after time, when a pattern of human exposure and adverse response could be observed, e.g., as reflected by the public health history with tobacco, mercury, asbestos, and thalidomide. It is therefore unsafe for the Dti to conclude that there is no environmental noise pollution from wind turbines without first conducting an independent acoustic and epidemiologic assessment.

41. The Dti Report uses the word *"perception"* and as this does not appear to be defined, one has to presume the authors are referring to *"perception of the auditory system"*, i.e., whether a sound is audible. The WHO *Guidelines for Community Noise 1999* states in S.2.1.6:

"Sound is a sensory perception evoked by physiological process in the auditory brain." [That is, the process of 'perceiving' sound is a biologic/ physiologic process.]

42. The Dti Report Conclusions [August 2006] state, on page 66:

"Community Noise, WHO 'there is no reliable evidence that infrasound below the hearing threshold produce physiological or psychological effects."

The Dti report repeats this quotation on pages 2, 10, 46 and 66. However, this quotation is taken from the ***WHO Community Noise Paper 1995*** **and does not appear in the final document of 1999.**

In fact, the WHO *Guidelines for Community Noise 1999* clearly states in Section 3.8:

"The evidence on low frequency noise is sufficiently strong to warrant immediate concern."

"Health effects due to low frequency components in noise are estimated to be more severe than for community noises in general (Berglund et al 1996)."

43. Other conclusions of the Dti Report on page 66 include:

"Infrasound noise emissions from wind turbines are significantly below the recognised threshold of perception for acoustic energy within this frequency range." (Below 20Hz)

There is significant medical evidence that infrasound is perceived by other organs in the human torso with negative health responses. (See Section 5, Health Effects, in this Review). The Dti Report measured at Site 2, Appendix 6C, levels of 40 – 50 dB between 10Hz-20Hz. The UKNA survey (S.4.52) measured 70dB below 20Hz on three wind farms. Both measurements are inaudible to the auditory brain (the ear), yet may medically have an impact on body organs.

44. Another conclusion from the Dti Report on page 66 states:

"It may therefore be concluded that infrasound associated with modern wind turbines is not a source which will result in noise levels which may be injurious to health of a wind farm neighbour."

There is no substantive epidemiological or physiological evidence in the Dti Report to support this conclusion.

The Dti Report does not address the physiological or biological responses of the human body. Acousticians – with experience working as consultants to the wind industry – produced the Dti report, and as acousticians, they focus on acoustic analysis, identifying the sound power levels [dB] down to around the threshold of audibility.

45. The Dti Report considered the 'individual thresholds of hearing', observing that:

'Measurements of the equal-loudness contours at frequencies below 20 Hz have been investigated by Moller and Andresen, and Whittle et al.' (p. 26)

In a comparison of the results of these studies, the *'measurements indicate good agreement between the two papers and indicate a continuing tendency for the contours to become closer as the frequency reduces. Therefore, in the* ***infrasonic range, an increase of the sound pressure level by 10 dB may be perceived as an 8 – 16 fold increase in loudness as compared to a doubling, 2 fold increase at 1 kHz [1,000 Hz]. The result of this change in perceived loudness with change in sound pressure level in the low frequency region is that small changes in the pressure level may be experienced as a large change in perceived loudness."*** [emphasis added] [Moller H; Andresen J. Loudness of pure tones at low and infrasonic frequencies. Journal of low frequency noise and vibration 1984; 3(2): 78 – 87; and Whittle LS; Collins SJ; Robinson DW. The audibility of low frequency sounds. Journal of sound and vibration 1972; 21: 431 – 448]

'Therefore, when infrasound and low frequency are of sufficient level to be detected, then a small change in pressure level above this threshold will quickly become perceived as a large change in loudness which may be considered unacceptable. The experience of the low frequency sufferers within the Salford Study [Proposed criteria for the assessment of low frequency noise disturbance. Report for Defra by Dr Andy Moorhouse et al, February 2005] *indicated that once the subject has been 'sensitised' to low frequency noise, then only a small increase in pressure level above the hearing threshold is required to be considered unacceptable.'* [Dti S.3.3, p. 27]

46. The Dti Report compares the difference in sound power level (dB) at infrasound frequency, between downwind and upwind wind turbines:

'Infrasound noise emissions were identified within a paper by Shepherd and Hubbard [Physical characteristics and perception of low frequency noise from wind turbines. Noise control engineering journal 1991 Jan/Feb; 36(1): 5 – 15] *which provided field data from a number of upwind and downwind rotor configuration wind turbines. The generation of blade passage frequency (BPF) energy and associated harmonics were found to be more dominant for downwind rotor configurations. This was due to the effect of the supporting tower wake interaction as the blade passed behind the tower and would experience a sudden and significant change to the airflow.'* [Dti S.5, p 32]

However, if one refers to Hubbard and Shepherd's '*Aeroacoustics of Large Wind Turbines*' [JASA Journal of the Acoustical Society of America 1991, figure 8, p 2499], the upwind wind turbines show a similar noise spectra, indicating sound pressure levels (dB) between 60 – 70 dB in the 1Hz – 20 Hz range. This compares with the Dti Report on upwind machines of between 50 – 60 dB in the 6 – 20 Hz range.

47. The Dti Report refers to infrasound noise immissions:

'The measured data indicates that wind turbines do increase the level of infrasound acoustic energy within the environment but that this energy is below the perception threshold.' [Dti p 36]

While the Dti Report provides evidence to support the view that the sound pressure level (dB) when below 20 Hz is below the threshold of audibility, the report provides no evidence to support the view that the noise is below the threshold of human perception. Indeed, a purely acoustics report cannot provide evidence in that regard, because humans are physiologically affected by inaudible sound. Inaudible sound affects not only humans, but also animals; e.g., animals retreated from the coastal areas of the tsunami that devastated parts of Asia in 2004, and sonar can affect whales and dolphins. [Mott M. Did animals sense tsunami was coming? National Geographic News, 4 January 2005. See also Section 4.11 of this paper.]

48. In identifying complaints from the three wind turbine sites where measurements were taken, the Dti Report noted: (pages 56-57)

'In general, the occupants of Site 1: Location 1 and Site 3: Locations 1 & 2, have described wind farm noise as being most intrusive within the dwellings during the night-time or early morning periods. The occupants have also indicated that the amplitude modulation of the aerodynamic noise is a character that draws their attention to the noise and which makes it readily identifiable when heard within an internal living space. The levels of external noise when the wind farms were considered to give rise to audible noise within the dwellings and specifically identified by the occupants ranged as follows:

Site 1 Location 1: 38.5 – 41.0 dB LAeq 10 min : 36.3 – 38.7 LA90, 10 min

Site 2 Location 1: 37.5 – 40.2 dB LAeq 10 min : 36.2 – 38.1 LA90, 10 min

Site 3 Location 1: 40.4 – 45.5 dB LAeq 10 min : 39.0 – 39.8 LA90, 10 min

'Irrespective of the existing background noise level at the time of the measurements, the external noise levels associated with the operation of the wind turbines meet the requirements of ETSU-R-97 for night-time operations' – the greater of 43 dB L_{A90} (or background + 5 dB) – *'i.e., noise levels are lower than 43 dB L_{A90}. This level provides protection against the awakening of an occupant, based upon the recordings, where no occupant was noted to awaken due to noise associated with the operation of the wind turbine.'*

'Measured internal noise levels for the same measurement periods detailed above are as follows: (page 60)

Site 1 Location 1: 22.7 – 24.6 L_{Aeq} 10 min : 21.8 – 22.5 dB L_{A90}, 10 min

Site 2 Location 1: 27.6 – 36.7 L_{Aeq} 10 min : 25.9 – 30.1 dB L_{A90}, 10 min

Site 3 Location 1: 42.5 – 53.1 L_{Aeq} 10 min : 41.6 – 42.0 dB L_{A90}, 10 min

Site 1, location 1 is within a double glazed conservatory with no windows open.

Site 2, location 1, is within a room with windows open.

Site 3, location 1, is within a room with windows open with the internal measurement location having a direct line of sight down to the stream in the valley below and the microphone placed within 0.3 m of the open window.'

[Authors' note: Compliance with the noise limits based on ETSU-R-97 does not imply that there will be no significant noise impact on local residents.]

49. The following are further examples of measurements forming part of the Dti report Appendix:

For example, Site 1, measurements taken on 16 May 2005, are within the frequency range of 10 Hz – 20 Hz, an L_{eq} dB of between 40 dB – 45 dB 'Low frequency noise audibility external façade', location 1:00:00 – 1:02:35 (figures 1 and 32).

For example, Site 2 measurements taken on 14 June 2006, '*Low frequency noise audibility internal before windows open*', an L_{eq} dB within the frequency range of 10 Hz – 20 Hz of between 40 – 45 dB was measured, Location 1:21:00 – 1:21:15 (figures 1 and 4).

50. This, however, portrays just a small part of the picture. To be useful, all wind turbine acoustic measurements should include the following information. This is because the rotation speed of the blades can be controlled remotely, especially when a noise management scheme is in place. The rotation speed (rpm) has a direct bearing on the noise emission from the wind turbine.

i. Distance of the measured point from nearest wind turbine;
ii. Measured point relative to the wind turbines (array impact);
iii. Wind speed and direction at the hub height;
iv. Actual revolutions per minute of the blades at the time of measurement – as this does not necessarily correlate to wind speed;
v. Difference in altitude between the measured point and the wind turbine;
vi. A definitive description of the terrain; and
vii. A dB(A) and dB(C) measurement of frequency down to 1 Hz.

51. Referring to Site 1, the Dti report [p 81] comments:

'It should be noted that the description of the noise by the awoken occupant was that the noise was "intolerable". The range in levels in the 400 – 500 Hz third octave bands was measured to lie between 9 – 10 dB and to be 17 dB above the B.S. ISO 226:2003 Threshold Criterion Curve. In this event, ***the perceived change in level in this frequency range would be a doubling of the perceived loudness, with levels potentially rising in and out of the Threshold of Audibility.*** [emphasis added] *This would give rise to a sound of a muffled swish that could be described as a heart beat type sound as the sound may only be audible for part of the time, i.e., as the noise associated with the wind farm is aerodynamic in origin and is associated with the rotation of the blades, then this will appear at 3 times the rotational speed also known as the blade passage frequency (bpf). The turbines operate with a rotational speed of 26 rpm, which equates to a blade passage frequency = 78 bpf. This is in the normal range of a heart beat.'* [p 81]

According to 'Measuring Sound', a publication from Bruel and Kjaer, a company that manufactures acoustical measuring and calibrating equipment used by many researchers and industries, when noise levels are too high and no other means of attenuation has worked or is feasible, then:

'Shut down the offending machinery. In severe cases, this step must be considered. It is also possible to limit the hours of operation.'
[Bruel and Kjaer. Measuring Sound, September 1984 (rev)]

52. In August 2006, the United Kingdom Noise Association (UKNA) published a report by John Stewart, ***'Location, Location, Location'***. This report, believed to be the first produced with input and evidence from both acoustic and medical resources and experts, addresses the cause of the suffering of families when wind turbines have been built too close to their homes:

'Our own conclusion, after reviewing the evidence ... So much depends on the location of the wind farm relative to where people live.'

The UK Noise Association measured noise levels around three wind farms: Bears Down (October 2005) in Cornwall; Bradworthy (December 2005) in Devon; and Blaen Bowi (October 2005) in Wales. (As previously mentioned it is believed that the Dti took its measurements at Bears Down– its Site 2; and Blaen Bowi – its Site 3.)

53. UKNA summarised its findings of wind turbine noise measured outdoors:

'At 10 Hz, the noise from the wind farms ranged from negligible (upwind from the turbines) to 75 dB (C) (downwind). Because 'Watanabe and Moller' figures are 'G' weighted and the UK Noise Association used 'C' weighting, only approximate comparisons are possible. But these findings are well within the 97 decibels where it would become a noise problem at 10 Hz, whatever the weighting.'

'At 20 Hz, the noise from the wind farms ranged from a low of 10 dB (C) (upwind of the turbines) to a high 82 dB (C) (downwind), with the great majority of the results falling in the 40 – 70 dB (C) range.' [p 14]

54. UKNA also tested for low frequency noise indoors. A house close to the Blaen Bowi wind farm was used (p 15):

"The results we obtained were these:

'At 10 Hz, the noise levels ranged from 44 to 48 decibels, well below the levels at which the noise could be heard. At 20 Hz, the noise levels ranged from 40 to 48 decibels, again well below audible levels. At 60 Hz, the noise levels ranged from 44 to 63 decibels, which suggests that low-frequency noise is being heard at times. At 100 Hz, the decibel levels ranged from 42 to 52 decibels, which indicates that the 'swish' sound is being heard, containing low frequency content.' "

55. The UKNA Report also stated:

<u>On page 19</u>: *'Conclusions on Noise and Health.*

- Pedersen's arguments are persuasive that the dancing shadows and the rotating blades can significantly add to the annoyance and stress caused by noise from the turbines. The questions being asked by some in the medical profession as to whether this cocktail of effects – the noise, low frequency, rotating blades, the shadows and the strobing – is leading to ill health out of proportion to the noise turbines make, needs serious examination.'

On page 20 - first conclusion: *'Overall Conclusions.*

> *1. Wind farm noise, in common with noise generally, affects different people in different ways, but the evidence suggests there is rarely a problem for people living more than 1 – 1.5 miles from a turbine.'*

On page 21 - first recommendation. *'Overall Recommendations.*

> ***It would be prudent that no wind turbine should be sited closer than 1 mile away from the nearest dwelling.*** *This is the distance the Academy of Medicine in Paris is recommending, certainly for the larger turbines and until further studies are carried out.* ***There may even be occasions where a mile is insufficient depending on the scale and nature of the proposed development.'***

56. The following charts from the UKNA survey confirm the presence of LFN. Using the WHO alternative measure (*Guidelines for Community Noise 1999*, S 2.1.2), *"when no frequency analysis is possible, the difference between A-weighted and C-weighted levels gives an indication of the amount of low frequency content in the measured noise."* The difference in two sample readings at Bradworthy (005 & 007), between A and C weighting was 29 and 30 decibels; at Bears Down (05 & 06), the difference was between 25 and 30 decibels; and at Blaen Bowi (005 & 006), the difference was between 26 and 27 decibels.

BRADWORTHY 05 Wind Direction SW speed 9 – 19 MPH Shielded from Wind

Location Hillside Farm SS 294 135

Microphone – 1Hz

Shielded from Direct Wind

Instrument:	2250	
Application:	BZ7223 Version 1.2	
Start Time:	07/12/2005 19:53:13	
End Time:	07/12/2005 19:56:20	
Elapsed Time:	00:03:07	
Bandwidth:	1/3-octave	
Max Input Level:	140.50	

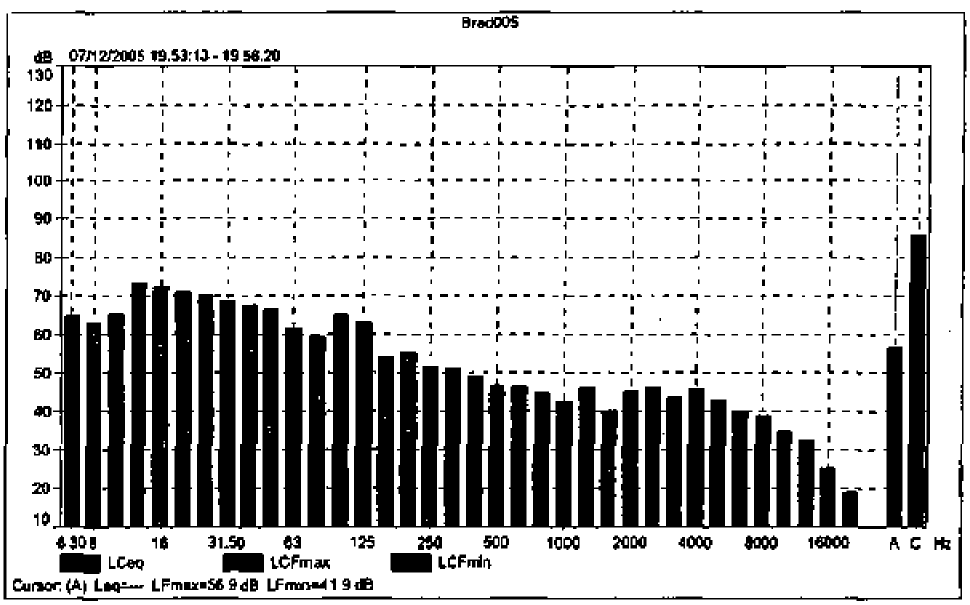
	Time	Frequency	
Broadband (excl. Peak):		FSI	AC
Broadband Peak:		C	
Spectrum:	FS	C	

Instrument Serial Number:	2505941
Microphone Serial Number:	2508682
Input:	Top Socket
Windscreen Correction:	None
Sound Field Correction:	Free-field

Calibration Time:	07/12/2005 14:47:11
Calibration Type:	External reference
Sensitivity:	52.78 mV/Pa

Brad005 Text

		Start time	End time	Elapsed time	Overload [%]	LAIeq [dB]	LAFmax [dB]	LAFmin [dB]
Value					0.00	47.7	56.9	41.9
Time		19:53:13	19:56:20	0:03:07				
Date	07/12/2005		07/12/2005					



BRADWORTHY 07 Wind Direction NW speed 9 – 23 MPH Shielded
from Wind

Location SS 304 135

Microphone – Normal

Audio File – Track Brad02

Instrument:	2250
Application:	BZ7223 Version 1.2
Start Time:	08/12/2005 11:19:27
End Time:	08/12/2005 11:24:07
Elapsed Time:	00:04:40
Bandwidth:	1/3-octave
Max Input Level:	141.24

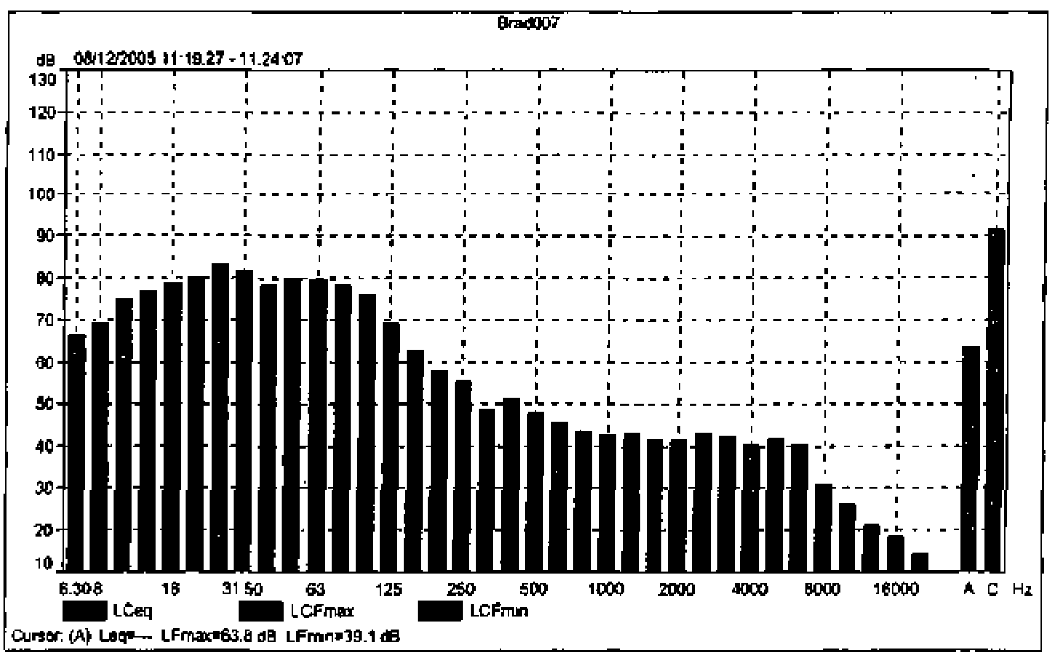
	Time	Frequency	
Broadband (excl. Peak):		FSI	AC
Broadband Peak:		C	
Spectrum:	FS	C	

Instrument Serial Number:	2505941
Microphone Serial Number:	2508682
Input:	Top Socket
Windscreen Correction:	UA 1650
Sound Field Correction:	Free-field

Calibration Time:	08/12/2005 09:45:31
Calibration Type:	External reference
Sensitivity:	48.41 mV/Pa

Brad007 Text

	Start time	End time	Elapsed time	Overload [%]	LAleq [dB]	LAFmax [dB]	LAFmin [dB]
Value				0.00	49.5	63.8	39.1
Time	11:19:27	11:24:07	0:04:40				
Date	08/12/2005	08/12/2005					



BEARSDOWN 05 Location SH 904 685

Wind Speed	12 – 15 MPH
Wind Direction	S
Microphone	Normal

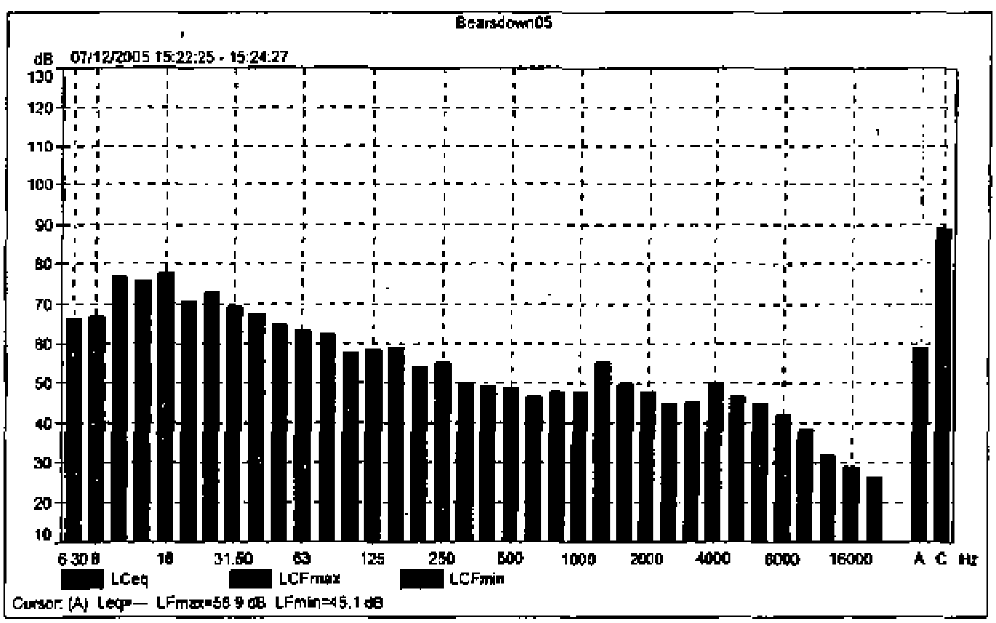
Instrument:		2250
Application:		BZ7223 Version 1.2
Start Time:		07/12/2005 15:22:25
End Time:		07/12/2005 15:24:27
Elapsed Time:		00:02:02
Bandwidth:		1/3-octave
Max Input Level:		140.50
	Time	Frequency
Broadband (excl. Peak):	FSI	AC
Broadband Peak:		C
Spectrum:	FS	C

Instrument Serial Number:	2505941
Microphone Serial Number:	2508682
Input:	Top Socket
Windscreen Correction:	None
Sound Field Correction:	*Free-field*

Calibration Time:	07/12/2005 14:47:11
Calibration Type:	External reference
Sensitivity:	52.78 mV/Pa

Bearsdown05 Text

		Start time	End time	Elapsed time	Overload [%]	LAIeq [dB]	LAFmax [dB]	LAFmin [dB]
Value					0.00	52.6	58.9	45.1
Time		15:22:25	15:24:27	0:02:02				
Date	07/12/2005		07/12/2005					



BEARSDOWN 06 Location SH 904 685

Wind Speed	10 – 18 MPH
Wind Direction	S
Microphone	1 Hz

Instrument:	2250
Application:	BZ7223 Version 1.2
Start Time:	07/12/2005 15:26:33
End Time:	07/12/2005 15:28:39
Elapsed Time:	00:02:06
Bandwidth:	1/3-octave
Max Input Level:	140.50

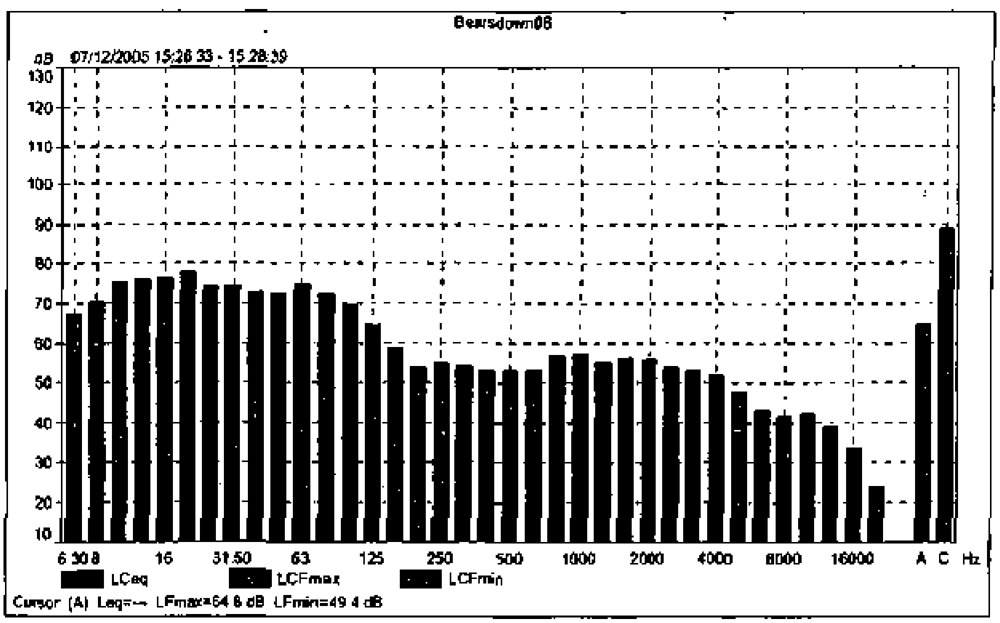
	Time	Frequency	
Broadband (excl. Peak):		FSI	AC
Broadband Peak:		C	
Spectrum:	FS	C	

Instrument Serial Number:	2505941
Microphone Serial Number:	2508682
Input:	Top Socket
Windscreen Correction:	None
Sound Field Correction:	Free-field

Calibration Time:	07/12/2005 14:47:11
Calibration Type:	External reference
Sensitivity:	52.78 mV/Pa

Bearsdown06 Text

	Start time	End time	Elapsed time	Overload [%]	LAleq [dB]	LAFmax [dB]	LAFmin [dB]
Value				0.00	57.2	64.8	49.4
Time	15:26:33	15:28:39	0:02:06				
Date	07/12/2005	07/12/2005					



BLAEN BOWI 005 No Filter Installed Location SN 32314 BNG 36829

Instrument:	2250
Application:	BZ7223 Version 1.2
Start Time:	01/12/2005 11:55:22
End Time:	01/12/2005 11:57:32
Elapsed Time:	00:02:10
Bandwidth:	1/3-octave
Max Input Level:	140.67

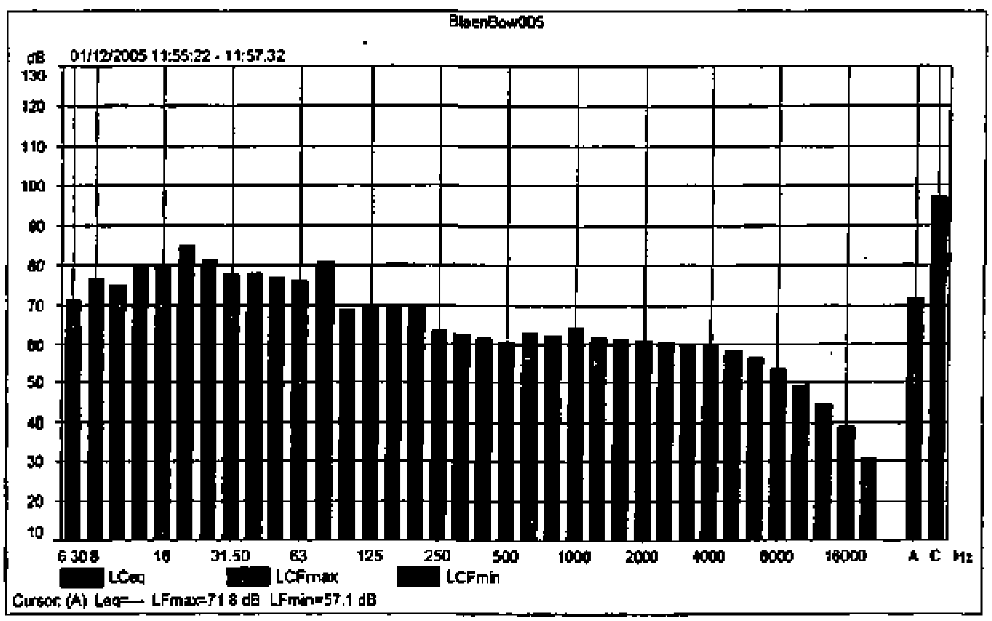
	Time	Frequency	
Broadband (excl. Peak):		FSI	AC
Broadband Peak:		C	
Spectrum:	FS	C	

Instrument Serial Number:	2505941
Microphone Serial Number:	2508682
Input:	Top Socket
Windscreen Correction:	UA 1650
Sound Field Correction:	Free-field

Calibration Time:	01/12/2005 10:12:59
Calibration Type:	External reference
Sensitivity:	51.65 mV/Pa

BlaenBow006 Text

	Start time	End time	Elapsed time	Overload [%]	LAIeq [dB]	LAFmax [dB]	LAFmin [dB]
Value				0.00	65.4	71.8	57.1
Time	11:55:22	11:57:32	0:02:10				
Date	01/12/2005	01/12/2005					



BLAEN BOWI 006 *Location SN 33081 BNG 35867*

Wind Speed 17 – 24 mph

Instrument:	2250
Application:	BZ7223 Version 1.2
Start Time:	01/12/2005 11:55:22
End Time:	01/12/2005 11:57:32
Elapsed Time:	00:02:10
Bandwidth:	1/3-octave
Max Input Level:	140.67

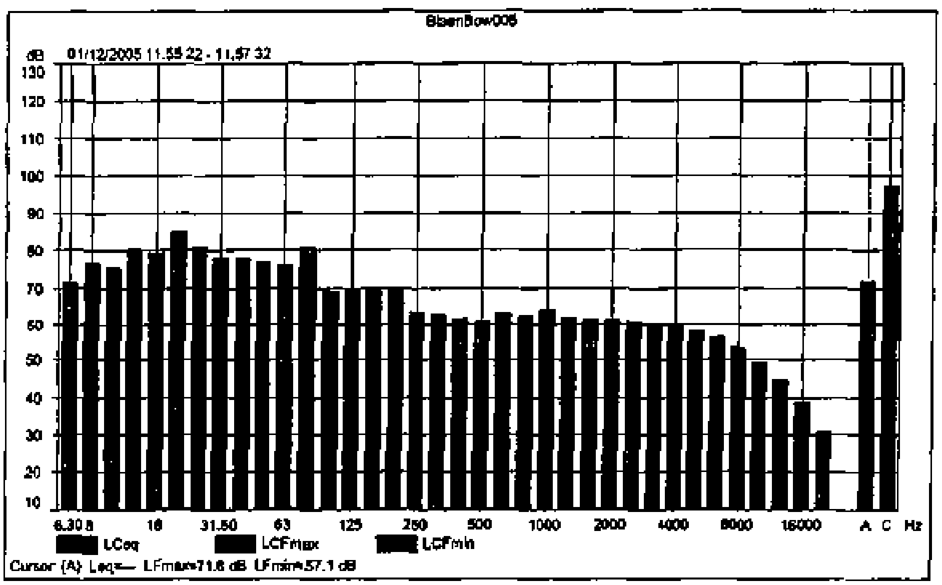
	Time	Frequency	
Broadband (excl. Peak):		FSI	AC
Broadband Peak:		C	
Spectrum:	FS	C	

Instrument Serial Number:	*2505941*
Microphone Serial Number:	2508682
Input:	Top Socket
Windscreen Correction:	UA 1650
Sound Field Correction:	Free-field

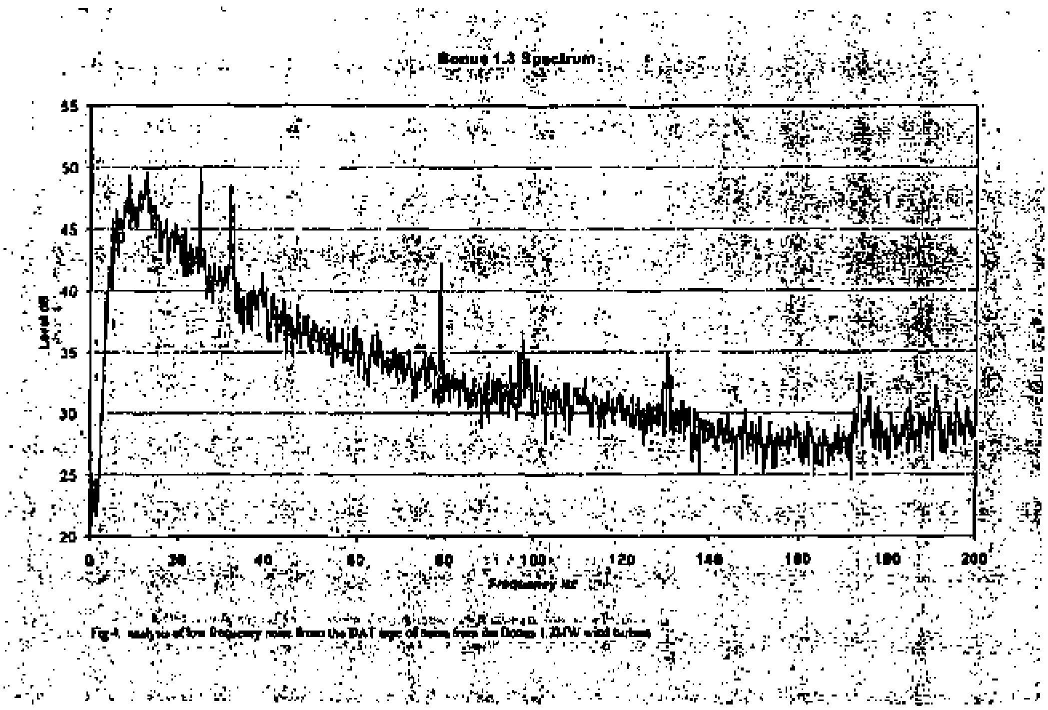
Calibration Time:	01/12/2005 10:12:59
Calibration Type:	External reference
Sensitivity:	51.65 mV/Pa

BlaenBow006 Text

		Start time	End time	Elapsed time	Overload [%]	LAleq [dB]	LAFmax [dB]	LAFmin [dB]
Value					0.00	65.4	71.8	57.1
Time		11:55:22	11:57:32	0:02:10				
Date	01/12/2005		01/12/2005					



57. The following chart is an analysis of low frequency noise from a DAT tape prepared by Delta, consultants for 'Bonus' of a Bonus 1.3MW wind turbine. The chart formed part of "A Report to Vale of the White Horse District Council"(UK) by Dr G Leventhall, March 2004:



It is significant that the noise measurements taken by UKNA correlate with the noise chart in the low frequency noise range, of the Bonus 1.3 MW wind turbine. However, the fall-off at 0Hz – 6Hz is a surprise and may be due to the instrumentation.

58. In a recent publication [Leventhall G. Infrasound from wind turbines – fact, fiction and deception. Canadian acoustics 2006 Jun; 34(2): 29 – 36], Geoffrey Leventhall, acoustician and consultant to Defra and Dti, writes that:

> *'Infrasound from wind turbines is below the audible threshold and of no consequence.'*

However, Leventhall does acknowledge that wind turbine noise can be problematic:

> *'Low frequency noise is normally not a problem, except under conditions of unusually turbulent inflow air.'*
>
> *'Turbulent air inflow conditions cause enhanced levels of low frequency noise, which may be disturbing, but the overriding noise from wind turbines is the fluctuating audible swish ...'*
>
> A wind turbines' main noise source is produced by the *'repeating sound of the blades interacting with the tower. This is the noise which requires attention, both to reduce it and to develop optimum assessment methods.'* [See also section 4.19 of this paper: Report by Styles et al; report by the US Department of Defense]

59. The suitability of using ETSU-R-97 as a guide for reasonableness is challenged by Dick Bowdler in *'ETSU-R-97: Why it is Wrong'* [July 2005]. The Bowdler Report comments:

On page 61 of ETSU-R-97, the Noise Working Group stated that:

> *'During the night one can reasonably expect most people to be indoors and it will not be necessary to control noise to levels below those required to ensure that the restorative process of sleep is not disturbed. A night-time absolute lower limit is therefore appropriate based upon sleep disturbance criteria.'* [ETSU-R-97]

Bowdler counters this assumption by the Noise Working Group [NWG] with the following:

> *'What this says is that a turbine noise level inside peoples' houses of just less than the World Health Organisation say is necessary to get back to sleep if you wake up in the night is satisfactory. It seems to me this must be the very upper limit of acceptability, not one that is well balanced. Since then, the WHO has revised its guidance 5 dB lower. So the ETSU night standard is now higher than WHO say you need to get back to sleep.'* [Bowdler, 3.15].

60. On page 62 of ETSU-R-97, the NWG wrote:

> *'It is also the opinion of the Noise Working Group that there is no need to restrict noise levels below a lower absolute limit of LA90, 10min = 33db(A); if an environment is quiet enough so as not to disturb the process of falling asleep or sleep itself then it ought to be quiet enough for the peaceful enjoyment of one's patio or garden.'* [ETSU-R-97]

Again, this conclusion relies on presumption; Bowdler responds:

> *'This is a bizarre statement. It seems that the 33dBA is the 35dB sleep restoration level set out by the World Health Organisation for inside bedrooms at night. They seem to be saying that there is no need for noise levels during the day to be any lower than is necessary to allow you to go to sleep on your patio on a sunny afternoon.'* [Bowdler, 3.16]

> *'Having suggested that 33dB would be satisfactory because people could get to sleep on their patio – they now say that "This level would however be a damaging constraint on the development of wind power in the UK as the large separation distances required to achieve such low noise levels would rule out most potential wind farm sites" [ETSU-R-97]. There is absolutely no evidence brought forward to justify this.* ***A margin of 2km would normally easily achieve this even with the noisier modern turbines.*** *They argue that "Wind farms have global environmental benefits which have to be weighed carefully against the local environment impact" [ETSU-R-97]. So do many other things. They argue that "Wind farms do not operate on still days when the more inactive pastimes (e.g. sunbathing) are likely to take place" [ETSU-R-97]. The suggestion seems to be that the protection of*

people's amenity does not include protecting them whilst sunbathing in their gardens on a slightly windy day or sleeping on the patio.' [Bowdler, 3.17]

'Then, on page 63 [of ETSU-R-97] there is another leap of credibility: "There is no evidence for or against the assertion that wind farm noise with no audible tones is acceptable up to and including LA90, 10min levels of 40dB(A) even when background noise levels are 30dB or less". This is just nonsense. There most certainly is evidence against this assertion. The 40dB is actually 42dB in BS4142 units. This is at least 12dB above background noise level of "30dB or less" and BS4142 says there are likely to be complaints at turbine levels of plus 10dB. Furthermore there is no argument that BS4142 is not applicable. Even BS4142:1990 (which was current when ETSU-R-97 was written) might easily be applicable here. If the wind speed is 5m/s, the background noise 30dB and the turbine noise 42dB(LAeq) then there is no reason not to use BS4142, it does not exclude itself in these circumstances. ***This noise level is also 12dB more than (twice as loud as) the WHO considers necessary for you to be able to get to sleep.'*** [Bowdler, 3.18]

61. In August 2005, the Renewable Energy Foundation (REF) released a statement that commented on the new report by GP van den Berg, *"The beat is getting stronger: the effect of atmospheric stability on low frequency modulated sound of wind turbines"* [Journal of Low Frequency Noise and Vibration 2005; 24:1-24].

Prof. Ffowcs-Williams, Emeritus Professor of Engineering, Cambridge University, one of the UK's leading acoustical experts and an advisor to REF said [REF Studies on wind turbine noise raise further concerns, 4 August 2005]:

'Van den Berg's paper adds weight to the criticisms frequently offered of the UK regulations covering wind turbine noise, ETSU-R-97. The regulations are dated and in other ways inadequate. It is known that modern, very tall turbines, do cause problems, and many think the current guidelines fail adequately to protect the public."

62. "Wind Energy" (published by John Wiley & Sons), a technical bimonthly journal of wind turbine engineering papers, provides evidence that confirms just how imprecise the forecasting of wind turbine performance is:

a *"Challenges in modelling the unsteady Aerodynamics of wind turbines"* by JG Leishman, Department of Aerospace Engineering, University of Maryland (USA) [Wind Energy 2002;5;85-132]:

"Such problems include the challenges in understanding and predicting the unsteady blade airloads and rotor performance, as well as predicting the dynamic stresses and aeroelastic response of the blades. Wind turbines are also subjected to complicated environmental effects such as atmospheric turbulence, ground boundary layer effects, directional and spatial variations in wind shear, thermal stratification, and the possible effects of an upstream unsteady, bluff body-like wake from support structure (tower shadow).

Fig. 1 [in original document] *summarises the various aerodynamic sources that may affect air loads on a wind turbine, which can be decomposed into a variety of mostly periodic and mostly periodic contributions. The net effect* *is that the wind turbine operates in an adverse unsteady aerodynamic environment that is both hard to define using measurements and also to predict using mathematical models."*

b "Survey of modelling methods for wind turbine wakes and wind farms" by A Crespo, J Hernandez, and S Frandsen [Wind Energy 1999;2;1-24]:

"The final report (intensified study of wake effects behind single turbines and in wind power wakes, National Power, London), indicates that the experimental and analytical studies reported (annex) point to significant energy losses in arrays spaced at less than seven turbine diameters. Similarly, turbulence may increase in arrays, sufficiently to cause measurable damage to fatigue and dynamic loads."

[Comment: In these circumstances, noise characters become more clearly pronounced.]

63. Morris et al further explain the difficulties [Morris PJ; Long LN; Brentner KS. An aeroacoustic analysis of wind turbines. American Institute of Aeronautics and Astronautics: AIAA-2004-1184; 42nd AIAA Aerospace Sciences Meeting, 5-8 January 2004, Reno, Nevada, 2004]:

'Since the wind turbine noise problem is very challenging, only some of the important noise sources and mechanisms are being considered [in this particular study]. *These are airfoil self-noise, the effects of blade rotation, and the propagation of sound over large distances.'*

Their research encompasses *'two aspects of airfoil self-noise ... The first is the relatively low frequency noise generated by deep stall and the second is trailing edge noise. The noise associated with blade rotation includes the effects of blade rotation on the blade aerodynamics, incoming gusts, incoming atmospheric turbulence and wind shear.'*

The authors add that:

'Wind turbines have aerodynamic and aeroacoustic behaviors with unique characteristics that make their prediction more challenging in many ways than already complicated aeroacoustic problems such as rotorcraft or propeller noise.'

Some of the challenges are due to the unpredictable and sudden changes in *'blade / inflow / tower wake interactions.'* Moreover, wind turbine flows are complex, moving through *'a varying atmosphere over an irregular terrain'*, with *'the blade speed varies linearly from root to tip'*:

'It would be unrealistic to suggest that all aspects of the wind turbine noise problem could be simulated within the framework of a single aerodynamics/ aeroacoustics code. The computational resources required to perform such a simulation will remain beyond the capabilities of available computers for many years.'

(Note: Interestingly, Morris et al use the permeable surface Ffowcs Williams-Hawkings formulation to couple unsteady flow simulations to the radiated noise field; see item 61 of this section, Acoustics, for Professor Ffowcs Williams's comments on ETSU-R-97.)

The authors further note that:

'While discrete frequency noise is certainly an important component of wind turbine noise (especially at low frequencies), broadband noise sources are also very important (especially at the higher frequencies).'

Additionally:

'However, the sound generated by wind turbines, particularly the low frequency components, may propagate large distances through an unsteady, non-uniform atmosphere over an irregular terrain. Atmospheric absorption can also be significant for the high frequency noise components. Thus, for wind turbine applications, sound propagation is an important component of the complete aeroacoustic problem.'

64. Sezer-Uzol and Long concur with Morris et al and observe that:

'... the acceptance of wind turbines by the public depends strongly on achieving low noise levels in application ... Furthermore, the acoustic propagation is of interest at relatively large distances from the wind turbine.' [Sezer-Uzol N; Long LN. 3-D time-accurate CFD simulations of wind turbine rotor flow fields. American Institute of Aeronautics and Astronautics: AIAA Paper No. 2006-0394, 2006; CFD = Computational Fluid Dynamics]

65. If the measure for setting a noise standard lacks credibility to many professionals, it is understandable why it lacks credibility to those suffering adverse health consequences. If the methodology is inadequate, then an impartial team of experts should redesign the measure. Moreover, until there are newly defined measures that conclusively work beyond reasonable doubt, the old measure should be withdrawn from use immediately and **an immediate minimum 2km zone placed between people's homes and wind turbines**. Greater separation may be necessary in specific circumstances or with a wind turbine of greater than 2MW installed capacity.

66. Moreover, as Paul Schomer noted in 2002 [Schomer PD. For purposes of environmental noise assessment, A-weighting needs to be retired. JASA Journal of the acoustical society of America 2002 Nov; 112(5, pt 2): 2412]:

'... for the purposes of environmental noise assessment, A-weighting needs to be retired ... A-weighting fails to properly assess multiple noise sources ... and it fails to properly assess sound with strong low-frequency content. It performs better outdoors than indoors even though the receivers are indoors. It certainly cannot be used for room noise criteria. A-weighted Leq cannot assess the audibility of sound, and in fact, Leq in fractional octave bands cannot be used to assess the audibility of sounds at low frequencies.'

[See also WHO *Guidelines for Community Noise 1999*, s.1.2 & s.3.9]

Schomer continues:

> *'There are better measures for all of these functions such as loudness-level rating using ISO 226. At low frequencies, data show some people (about one-third) are "C-weighted" listeners. For all noise, it may be that one model just does not fit all. Experiments show that a majority of listeners make categorical judgments and merely count events based on level with the minority of subjects fitting three other models. There are many ways to clearly move forward but we must give up our A-weighting, it has now reached old age.'*

67. According to Berglund et al [Berglund B; Hassmen P; Soames Job RF. Sources and effects of low-frequency noise. JASA Journal of the acoustical society of America 1996 May; 99(5): 2985 – 3002]:

> *'Low frequency noise is common ... as an emission from many artificial sources: road vehicles, aircraft, industrial machinery, artillery and mining explosions, and air movement machinery including wind turbines, compressors, and ventilation or air-conditioning units. The effects of low-frequency noise are of particular concern because of its pervasiveness to numerous sources, efficient propagation, and reduced efficacy of many structures (dwellings, walls, and hearing protection) in attenuating low-frequency noise compared with other noise ... Although the effects of lower intensities of low-frequency noise are difficult to establish for methodological reasons, evidence suggests that a number of adverse effects of noise in general arise from exposure to low-frequency noise ...* [p 2985]
>
> *... standards should consider the option of allowing less noise in the low-frequency range since the possibility exists that a stimulus may have an effect even without conscious (auditory) detection. Definitive solutions to these problems would require unethical exposures to low-frequency noise ... The balance of probability would appear to favour the conclusion that low-frequency noise has a variety of adverse effects on humans, both physiological and psychological ... The evidence provided ... warrants concerned action without the potentially extremely lengthy delay that may be occasioned by waiting for definitive proof which may never arise.* [p 2998]

68 Noise from wind turbines combines with visual phenomena such as shadow flicker, which compounds the adverse impact on those living nearby. R Bolton, who is president of a company that develops engineering software, observes in his report on shadow flicker:
[Bolton R. Evaluation of Environmental Shadow Flicker Analysis for "Dutch Hill Wind Power Project". Environmental Compliance Alliance, New York, USA, 30 January 2007]

> *'Large scale shadow flicker is a new phenomenon, not experienced by people on an "industrial scale", with football field sized shadows moving across their home or through their local views. As a new source of environmental pollution extra care is needed when evaluating the long term consequences.'*

For example, on elevated ridges with wind turbines that are 400 feet high, the turbines *'will cast shadows for thousands of feet, well above any vegetative screening'*.

Shadow flicker is not only a day-time phenomenon; night-time flicker is also problematic. Conditions for shadow flicker include moon-lit nights, with the rising and setting of the moon. Moreover, ridgeline wind turbines can cast shadows that *'easily extend 2 to 4 miles'*:

> *'Residents and passers-by (highway traffic) not immediately within the shadow will nevertheless readily observe the shadow flicker ...'*
>
> *'Often numerous wind turbines are sited linearly if placed on a ridgeline and nearby residents will be exposed to numerous shadow flickers simultaneously.'*

That is, all three blades of each wind turbine will create flicker, and the flicker from all the wind turbines will not be synchronised.

According to the UK's Planning Guide for Renewable Energy: a companion guide to PPS22 (2004), *'flicker effects have been proven to occur only within ten rotor diameters of a turbine'*. Meridian Energy, a wind farm developer, recommends that *the 'nearest affected receptors'* to a wind turbine producing shadow flicker, *'should be no closer than 10 turbine rotor diameters'*.

For a wind turbine with a 300-foot rotor diameter, the nearest receptor to shadow flicker should be no closer than 3000 feet.

In New York State (USA), the Department of Environmental Conservation Program Policy provides guidance for the phenomenon of shadow flicker:

> *'A properly sited and designed project is the best way to mitigate potential impacts.'*

The guidance specifies that:

> *'It is the burden of the applicant to provide clear and convincing evidence that the proposed design does not diminish the public enjoyment and appreciation of the qualities of the listed aesthetic resource.'*

Recognising the impact of shadow flicker, the Swedish building authority introduced a rule that the calculation of shadow flicker should be made for the building lot (garden), instead of only the window of a façade.

Bolton concludes that:

> *'... shadow flicker is a serious environmental pollutant that can have significant harmful effects on the welfare of persons subjected to it.*

When coupled with the noise pollution and visual degradation that many residents will be subjected to, it is clear that wind farm turbine setbacks should be increased to a minimum of 3,000 feet from any residence.'
[Bolton R. Evaluation of Environmental Shadow Flicker Analysis for "Dutch Hill Wind Power Project". Environmental Compliance Alliance, New York, USA, 30 January 2007]

69 This Section of the Review, **Acoustics**, provides evidence that the noise radiation from wind turbines is made up of a number of sound characters, which include low frequency noise (0Hz – 200Hz), infrasound (0Hz – 20Hz), vibration, rhythmic pulsation, and tonal qualities. Moreover, the noise combines with visual phenomena, such as strobe effects and shadow flicker, which can act synergistically with the acoustic qualities in the effects on people nearby. A prolonged dose at an appropriate level of any of these characters individually can evoke serious physiological changes in the human body, with health consequences.

Wind turbines emit a cocktail of acoustic characters and are delivered with a rhythmic, pulsating character, all of which can combine to create serious health responses from people if the wind turbines are constructed too close to their dwellings.

The ETSU-R-97 guidelines endorsed by the Dti do not protect families from the sleep deprivation and the consequent health effects where wind turbines are built too close to their homes.

Peter Hadden

Section 5.0 HEALTH EFFECTS

1 Levels of sound, both audible and inaudible (including that in the low frequency range) can have an adverse effect on health, not only psychologically, but also physiologically, with medical consequences. As previously discussed, wind turbines emit noise radiation, both audible and inaudible (including that in the low frequency range). The industry has struggled to accurately predict and control wind turbine noise and its impact on people in nearby dwellings, with inconsistent results. When installed near homes, the noise is not merely a persistent, unremitting nuisance. Whether in the UK, the US, Canada, the Netherlands, Australia, or elsewhere, those living near wind turbines share similar health and medical complaints.

2 Measuring the audibility of noise does not take into consideration that the human body also receives sound characters without the involvement of the auditory system.

3 Merely focusing on audible sound ignores the harmful impacts on human body organs of low frequency noise, vibration, and the whole combination of characters – e.g., pulsations – that act in combination to exacerbate the impact on the body's organs.

4 Acousticians measuring noise near wind turbines do not take into account the physiologic/medical aspects of the effects of noise, as this is not their area of expertise; only those with backgrounds in medicine, the human biologic sciences, and epidemiology can properly study the effects and responses of the human body to wind turbine noise.

5 Moreover, measuring the audibility of a sound, its loudness, and its characteristics does not account for the dose received. Dosimetry is an important part of the equation when considering the effects of noise on human health. Although one may acclimatise to certain noises, wind turbine noise, with its pulsating nature, varying harmonics and low frequency components, does not have a time-limit factor, and continues day after day and year after year, unlike noise at work, e.g., which has a time-limit factor. Because the impact on body organs builds over a long period of time, wind turbine noise is difficult to replicate in laboratory experiments. Moreover, it would be unethical to subject people to extended exposure in the laboratory setting.

6 According to 'Occupational and Community Noise', World Health Organisation Fact Sheet No 258 (February 2001, drawn from the WHO *Guidelines for Community Noise 1999*):

> *'The noise problems of the past are incomparable with those plaguing modern society ... the thumps and whines of industry provide a noisy background to our lives. But such noise can be not only annoying but also damaging to the health, and is increasing with economic development.*
>
> ***Health Impact.*** *The recognition of the noise as a serious health hazard as opposed to a nuisance is a recent development and the health effects of the hazardous noise exposure are now considered to be an increasingly important public health problem.*

- *Prolonged or excessive exposure to noise whether in the community or at work, can cause permanent medical conditions, such as hypertension ... (ref WHO Guidelines p XII).*
- *Noise can adversely affect performance, for example in reading, attentiveness, problem solving and memory. Deficits in performance can lead to accidents (ref WHO Guidelines p XII).*
- *A link between community noise and mental health problems is suggested by the demand for tranquillizers and sleeping pills ...'*

7 The WHO fact sheet continues:

> Noise may *'interfere with communication, disturb sleep, cause cardiovascular and psycho-physiological effects, reduce performance, and provoke annoyance responses and changes in social behaviour ... Many countries have regulations on community noise from rail, road, construction and industrial plants based on emission standards, but few have any regulations on neighbourhood community noise, probably owing to difficulties with its definition, measurement and control. This and the insufficient knowledge of the effects of noise on people handicap attempts to prevent and control the problem.'*

Environment	**Critical Health Effect**	**Sound Level dB(A)***	**Time hours**
Outdoor living areas	Annoyance	50 – 55	16
Indoor dwellings	Speech intelligibility	35	16
Bedrooms	**Sleep disturbance**	**30**	**8**
School classroom	Disturbance of communication	35	During class

Source: Who Fact Sheet No 258, Occupational and Community Noise, February 2001.

The WHO *Guidelines for Community Noise 1999* state that:

> *"The potential health effects of community noise include hearing impairment; startle and defense reactions; aural pain; ear discomfort; speech interference; sleep disturbance; cardiovascular effects; performance reduction; and annoyance responses. These health effects, in turn, can lead to social handicap; reduced productivity; decreased performance in learning; absenteeism in the workplace and school; increased drug use; and accidents. In addition to health effects of community noise, other impacts are important such as loss of property value."*

8 Indeed, the human body does emanate measurable 'sound', which can be detected by various testing equipment, as is used for excluding the presence of or for diagnosing disease. For example, in 'EEG measurement', G Blundell notes that

The brain operates	Normal activity	13 – 30 Hz
	Relaxed	8 – 13 Hz
	Drowsiness	4 – 7 Hz
	Deep sleep	0.5 – 4 Hz

[See also Hedge, A. 'Whole body vibration', Cornell University, April 2002; SafetyLine Institute, Government of Western Australia, 'Whole body vibration effects on health', 1998]

9 In the paper, "Human Body Vibration Exposure and its Measurement", G. Rasmussen looked at body vibration exposure at frequencies of 1 Hz – 20Hz. This chart details some of the findings:

Symptoms	**Frequency**
General feeling of discomfort	4Hz – 9Hz
Head symptoms	13Hz – 20Hz
Influence on speech	13 Hz – 20 Hz
Lump in throat	12 Hz – 16Hz
Chest pains	5Hz - 7Hz
Abdominal pains	4Hz - 10Hz
Urge to urinate	10Hz – 18Hz
Influence on breathing movements	4Hz – 8Hz

10 Rasmussen's 'mechanical man' illustrates these distributions:

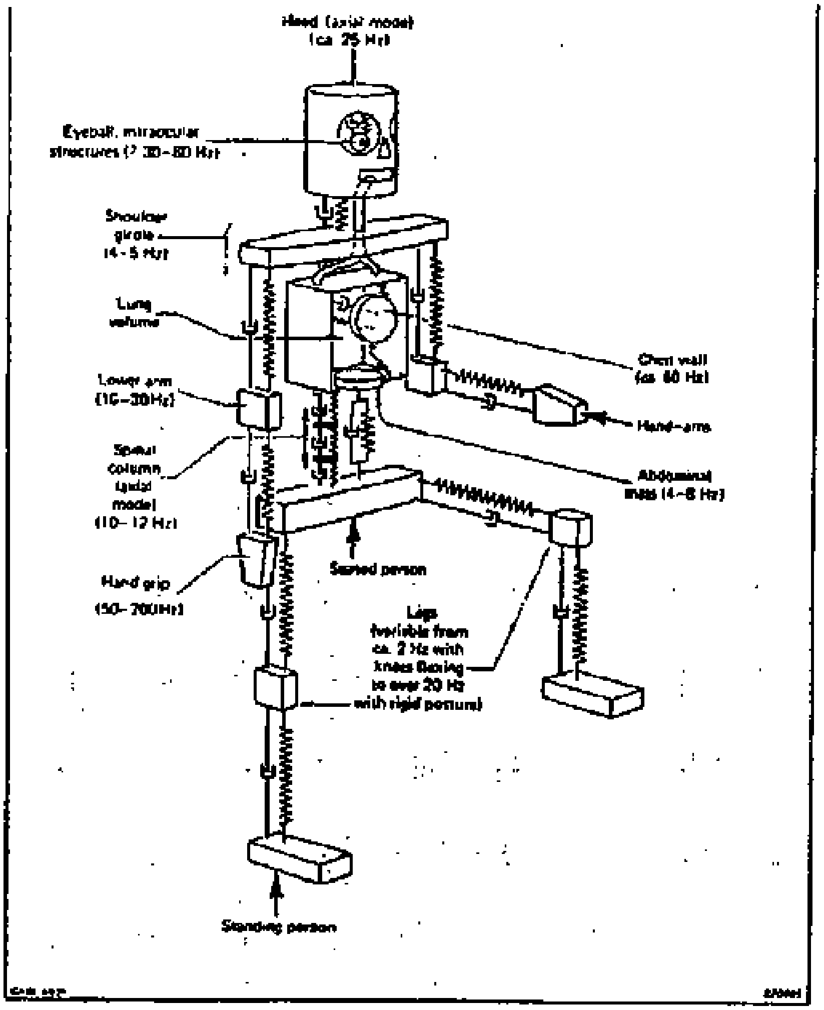


Fig. 1. Simplified mechanical system representing the human body standing on a vertically vibrating platform

Note that the head will vibrate at about 25 Hz and the chest wall at 60 Hz.

> *"Also, in the region 60 to 90 Hz disturbances are felt which suggest eyeball resonances, and a resonance effect in the lower jaw-skull system has been found between 100 and 200Hz."*

11 In "Community Noise Rating" [2d ed, Applied Science Publishers, 1982], the author, Theodore Shultz, wrote that the International Standards Organisation (ISO) had recently (1982) adopted a "Guide for the Evaluation of Human Exposure to Whole-Body Vibration".

In evaluating low frequency noise and vibration, he noted that there are:

> *"... four physical factors of primary importance in determining the human response to vibration: the* ***intensity****, the* ***frequency****, the* ***duration****, (exposure time) and the* ***direction*** *of the vibration."*

12 Shultz gives limits for longitudinal (2–axis) and for transverse (x–and y–axis) vibration respectively. Each curve, or boundary, represents a limit beyond which exposure to vibration carries a significant risk of fatigue or impaired working efficiency. Shultz comments:

> *"The 'exposure limit' boundaries are similar in general form to those for fatigue: but they lie 6 dB higher and the boundaries for reduced comfort have a similar form but lie 10dB lower than the fatigue boundaries."*
>
> *"The Standard mentions in a note that the criteria of acceptability in residential contexts, particularly at night, may lie near the threshold of detectability; for frequency bands of greatest sensitivity (4 – 8Hz for longitudinal, and 1 – 2 Hz for transverse vibration), this lies in the vicinity of 0.01m/s, (though it varies greatly in individual circumstances)."*

Merely as a rough guide, the longitudinal acceleration limits for fatigue indicates that for 0.20 rms between 10Hz – 20Hz, the limits of exposure should not exceed 24hrs – 30hrs. For transverse exposure, the limit is only 10hrs. [Authors' note: See also Section 4.18 or this Review]

13 In his coursework description of "Whole Body Vibration", Prof Alan Hedge of Cornell University writes:

> *"Vibrations in the frequency range of 0.5Hz to 80Hz have significant effects on the human body.*
>
> *Individual body members and organs have their own resonant frequencies and do not vibrate as a single mass, with its own natural frequency. This causes amplification or attenuation of input vibrations by certain parts of the body due to their own resonant frequencies.*
>
> *The most effective resonant frequencies of vertical vibration lie between 4Hz and 8Hz.*
>
> *Vibrations between 2.5 and 5Hz generate strong resonance in the vertebra of the neck and lumber region with amplification of up to 240%.*
>
> *Vibrations between 4 and 6Hz set up resonances in the trunk with amplification of up to 200%.*
>
> *Vibrations between 20 and 30Hz set up the strongest resonance between the head and shoulders with amplification of up to 350%.*
>
> *Whole body vibration may create chronic stresses and sometimes even permanent damage to the affected organs or body parts."* [Hedge A. Whole body vibration. DEA350, April 2002, c January 2006]

14 The SafetyLine Institute (Government of Western Australia) notes in its documentation and coursework:

> *"Prolonged exposure to whole body vibration at frequencies below 20Hz results in hyperventilation, increased heart rate, oxygen intake, pulmonary ventilation and respiratory rate.*

Digestive system disease often observed in persons exposed to whole body vibration over a long period of time. Associated with the resonance movement of the stomach at frequencies between 4 and 5 Hz.

Spinal column disease and complaints, perhaps the most common disease associated with long term exposure to whole body vibration, where the back is especially sensitive to the 4 – 12Hz range."

15 One of the most important parts of the body with respect to vibration and shock appears to be the abdomen with the resonance occurring in the 4 – 8 Hz range. The other main resonant effect is found in the head and neck region, with a range of 20 – 30 Hz. Eyeball resonance is similar, with vibration in the range of 25 – 90 Hz. *'The skull itself has a fundamental mode of of vibration in the region of 300 – 400 Hz.'* [SafetyLine Institute of WorkSafe Western Australia, Department of Consumer and Employment Protection, Government of Western Australia, 'Identification of whole-body vibration: Effects on Health', SLI 1998]

16 Another study concurring with these results looked at human body vibration induced by low frequency noise in the range of 20 – 50 Hz:

> *"The level and rate of increase with frequency of the vibration turned out to be higher on the chest than on the abdomen."* [Takahashi Y; Yonekawa Y; Kanada K; Maeda S. A pilot study on the human body vibrations induced by low frequency noise. Industrial health 1999 Jan; 37(1): 28-35]

17 Berglund, Hassmen, and Job, in "Sources and effects of low frequency noise", [Berglund B, Hassmen P, Job RF. JASA Journal of the acoustical society of America 1996 May; 99(5): 2985 – 3002] made these observations:

> *"The setting of the arbitrary lower limit of human hearing determines the lower limit of low frequency noise and the upper bound of infrasound. Such a setting is not a matter of absolutes. The threshold of hearing for tones and frequency bands depends on the loudness as well as the frequency and duration. In this sense, logically, human hearing capacity extends well below the 20 Hz range if one considers a signal that is sufficiently loud. Thus the threshold of absolute hearing extends well into the nominal infrasound range. It has been suggested that at very low frequencies human detection does not occur through hearing in the normal sense. Rather, detection results from nonlinearities of conduction in the middle and inner ear which generate harmonic distortion in the higher, more easily audible frequency range (von Gierke and Nixon 1976). This account does not dictate that the noise is not heard but rather that the method of hearing is indirect, as indeed is the mechanical method of all hearing (i.e. the relevant nerves are fired by changes in other biological structures in the ear, not directly by noise itself)."*

> *"Second, regardless of the process by which a sound wave is detected, it is critical to consider waves which are detected through skeletal bones, the ear, harmonics, tactile senses or resonance in body organs. Detection raises the possibility of subjective reactions such as annoyance, and annoyance*

may contribute in complex ways to other biological and psychological effects of the signal (Job 1993, Stansfield 1992.)"

"Third, determination of health and other effects of LFN must consider field data. Real occurrences of low frequency noise will often include considerable energy below 20Hz as well as energy in what is usually considered the LFN range. Thus the arbitrary setting of a cut off at 20Hz is not conducive to analysis of such data."

"The determination of precisely what constitutes LFN is also not perfectly clear in terms of its upper limit. Sound up to 250Hz are sometimes referred to as LFN although others have set the upper limit of the range to 100Hz (e.g. Backteman et al 1983a)."

18 In referring to impulsive noise, Berglund et al commented:

"... impulsive noise generates greater levels of subjective reactions such as annoyance and dissatisfaction than does non-impulsive noise of the same energy level."

The authors referred to the fact LFN travels extended distances with very little energy loss:

"... as the frequency wave is lowered, more of the energy enters the ear, the body and other objects (von Gierke & Nixon 1976). Thus LFN transmission extends into many objects allowing it to set up resonant vibration in our dwellings and our possessions as well as our chest cavities, sinuses, and throat." [Berglund et al]

19 Although within the aircraft industry, in extensive research on vibroacoustic disease (VAD, i.e., LFN-induced pathology), Dr M Pereira found that:

'... when continuous LFN is present in the home it can cause VAD. When pulsating LFN is experienced in the home it can aggravate the LFN induced pathology, either by making particular signs and symptoms more severe or by accelerating the onset of other signs and symptoms.

*'Mainstream concepts hold that acoustical phenomena impact the human body through the auditory system. While this may be true for certain regions of the acoustical spectrum, there are other regions of the acoustical spectrum (0 – 250Hz – LFN) where acoustical phenomena impact the human body **without** the involvement of the auditory system. **So any study that tries to understand the effects of LFN, as it is perceived by the auditory system is missing the point.**'*

20 For those in work environments with extended exposure to large pressure amplitude and LFN (LPALF), e.g., for aircraft technicians, vibroacoustic disease is an occupational health hazard, a disease process that was studied extensively after patterns of health problems were observed.

21 In one study by Castelo Branco et al [Castelo Branco NA, Rodriguez E, Alves-Pereira M, Jones DR. Vibroacoustic disease: some forensic aspects. Aviation, space, and environmental medicine 1999 Mar; 70(3 Pt 2): A145-51], among 236

aircraft technicians, the disabilities manifested themselves after a minimum of 16 years. Disabilities included neurological (34%), psychiatric (9.7%), cardiovascular (6.8%), and osteoarticular (5.9%). Echocardiograms (EEGs) showed 'characteristic changes in pericardial strucmres', with five pericardial layers instead of three.

Among the study participants, 73% were disabled after an average of 24 years.

22 An important aspect of these studies is the observation that not only can noise have adverse health effects, but also that low frequency noise can adversely impact the human body. This is because, to reiterate, although people perceive sounds and noise via the auditory system:

> ***"Acoustical phenomena impact the human body without the involvement of the auditory system"*** and ***"any study that tries to understand the effects of LFN, as it is perceived by the auditory system is missing the point".*** [M Alves-Pereira]

23 In 2002, Moller and Lydolf [Moller H and Lydolf M. A survey of complaints of infrasound and low frequency noise. Journal of low frequency noise, vibration and active control 2002; 21(2): 53-63] reported on 198 persons who had reported complaints about noise, identified as infrasound and low frequency noise:

> *"Their verbal reports often described the sound as deep and humming or rumbling, as if coming from the distant idling engine of a truck or pump. Nearly all respondents reported a sensory perception of sound. In general they reported that they perceived the sound with their ears, but many mention also the perception of vibration, either in the body or external objects."*

The authors continue:

> *"The sound disturbs and irritates during most activities, and many consider its mere presence as a torment to them. Many of the respondents reported secondary effects, such as insomnia, headache and palpitation. Typically, measurements have shown that existing limits (and hearing thresholds) are not exceeded."*

Moller and Lydolf suggest that there is ample evidence to pursue this research issue further, including the frequencies and levels involved.

24 Research published in 2003 on low frequency and broadband noises and annoyance [Pawlaczyk-Luszczynska M, Dudarewicz A, Waszkowska M, Sliwinska-Kowalska M. Assessment of annoyance from low frequency and broadband noises. International journal of occupational medicine and environmental health 2003; 16(4): 337-43] shows that:

> *"LFN was rated as significantly more annoying than BBN at the comparable A-weighted sound pressure levels. The annoyance assessment of either noise did not depend on age, length of employment or the level of exposure to noise at a current workplace. LFN presents a high risk of influencing human well-being ..."*

Indeed, additional studies, most in controlled environments and laboratories, have confirmed their findings.

25 In a 2004 study conducted at the Nofer Institute of Occupational Medicine in Lodz, Poland, the authors wrote [Pawlaczyk-Luszczynska M, Dudarewicz A, Waszkowska M, Szymczak W, Kamedula M, Sliwinska-Kowalska M. The effect of low frequency noise on human mental performance [article in Polish]. Medycyna pracy 2004; 55(1):63-74]:

> *'There is a growing body of data showing that low frequency noise (LFN) defined as broad band noise with dominant content for low frequencies (10 – 250 Hz) differs in its nature from other noises at comparable levels. The aim of this study was to assess the influence of LFN on human mental performance. Subjects were 193 male paid volunteers ... LFN at 50 dB(A) could be perceived as annoying and adversely affecting mental performance (concentration and visual perception) ...*

26 In another study by this group of 96 men and women, [Pawlaczyk-Luszczynska M, Dudarewicz A, Waszkowska M, Szymczak W, Sliwinska-Kowalska M. The impact of low frequency noise on human mental performance. International journal of occupational medicine and environmental health 2005; 18(2): 185 - 198], the authors note that:

> *"Low frequency noise differs in it nature from other environmental noise at comparable levels, which are not dominated by low frequency components."* [See also Berglund et al, Sources and effects of low frequency noise, JASA 1996]

Pawlaczyk-Luszczynska et al continue:

> *"Recent investigations show that low frequency noise at relatively low A-weighted sound pressure levels (about 40 – 45 dB) can be perceived as annoying and adversely affecting the performance, particularly when executing more demanding tasks. Moreover, persons classified as sensitive to low frequency noise may be at a higher risk."*

> The results of this study *"supports a hypothesis that LFN at levels normally occurring in the control rooms (at about 50 dB(A)) might adversely influence the human mental performance and lead to work impairment."*.

> These authors also note *that "previous studies on the effects of community LFN (in dwelling rooms) showed that subjects sensitive to this type of noise were not necessarily sensitive to noise in general as measure by noise sensitivity scales ... Sensitivity to this special type of noise [LFN] was somewhat different from sensitivity in general."*

> *"LFN at relatively low A-weighted SPL (about 40 dB) could be perceived as annoying and adversely affecting the performance, particularly when mentally demanding tasks were executed ... "* [see also Persson Waye et al, Low frequency noise pollution interferes with work performance. Noise and health 2001 Oct-Dec; 4(13): 33 – 49]

Letter Submitted 2/11/09

THE "HOW TO" GUIDE

TO

CRITERIA FOR SITING WIND TURBINES TO PREVENT HEALTH RISKS FROM SOUND

By:

George W. Kamperman, P.E.
INCE Bd. Cert. Member Emeritus
Fellow Member Acoustical of America
National Council of Acoustical Consultants
Kamperman Associates Inc
Wisconsin Dells, Wisconsin
george@kamperman.com

Richard R. James, INCE
E-Coustic Solutions
rickjames@e-coustic.com

"A subset of society should not be forced to bear the cost of a benefit for the larger society." [1]

Introduction

One of the founding principles in the United States is encapsulated in the quote above. Today in a significant number of rural communities residents believe this principle is under challenge by the current push for renewable energy sources, especially those related to industrial-scale wind turbines (WTi). The U.S. is a latecomer to the wide spread use of wind turbines as an integral part of the electrical utility system. The construction of large WTi projects in the U.S. is a relatively recent phenomenon, with most of the projects occurring after 2002. Other countries, especially in Europe and the U.K., have been using wind energy systems since the early 1990's and in some cases even earlier. Wind energy in those countries where WTi locations are optimum for production of electricity, produce a substantial amount of electricity for internal use or export. These early projects were often installations of wind turbines with less than 1 MWatt generation capacity and with hub heights under 200 feet. Now, many of these early wind energy projects are near the end of their life cycle and are being replaced with the larger industrial grade WTi unit with capacities of 1.5MWatts to 3 or more MWatts. The concepts and recommendations of this article may be applicable outside the U.S. as older wind farms are upgraded to the larger 1.5 MWatt and larger WTi.

If one listens to the people who see industrial wind turbines as the answer to the energy concerns in the U.S. one would think that the wind turbines are perfectly compatible with rural communities. Our State and Federal Governments and their agencies make the same claims about compatibility. Some States have established guidelines and direct local county and township governments to adopt these draft ordinances for their own use.

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[1] George S. Hawkins, Esq., *"One Page Takings Summary: U.S Constitution and Local Land Use,"* Stony Brook-Millstone Watershed Association
"...[N]or shall private property be taken for public use, without just compensation."
Fifth Amendment, US Constitution.

On the other hand, if one listens to the various community action groups that have been organized in almost every community where WTi projects have been announced the situation is just the opposite. The members of those groups believe there is ample reason to challenge criteria set in the State Draft Ordinances and actively petition their local governments to adopt stricter guidelines. To them, WTi will cause excessive noise at or in their homes. Other concerns include vibration and potential health risks to the community. Those who live the closest to the WTi host sites feel they are asked to bear the largest share of the burdens and risks of living near the industrial wind turbine project.

Who is correct? How does one know who to believe? Indeed, does anyone know the whole truth?

When faced with a new situation it is often worthwhile to see if one can learn from the experiences of the 'early adopters.' In the U.K., for example, there are currently about 133 operating WTi developments. Many of these have been operational for over 10 years. The Acoustic Ecology Institute (AEI) cites one study conducted for the British government in its AEI Special Report titled: "Wind Energy Noise Impacts[2]" that found only about 20% of wind farms tend to generate noise complaints. Another study done for the British government by the consulting firm Hayes, McKensie[3] reported that only five (5) of 126 wind farms in the U.K. reported problems with the phenomenon known as Aerodynamic Modulation (AM). Thus, experience in the U. K. shows that not all WTi projects lead to community complaints. The question posed by AEI to these findings in its report is: "**What are the factors in *those* wind farms that may be problematic, and how can we avoid replicating these situations elsewhere?**"

One might expect that the wind industry itself, given the European and U.K. experiences, would have conducted extensive research using independent research institutions to answer this question. The wind industry was aware of, or should have been aware of, the complaints of noise and/or vibration from people living near the "20%" of the projects that are recognized as having problems. Particularly considering there are more stringent noise limits in those countries than are being promoted in the U.S. As discussed later, the wind industry is aware of and follows criteria limiting the WTi to L_{90}+5 dBA limits in some countries or the fixed limits of not-to-exceed 30-40 dBA at night in rural and residential areas of Germany.

A serious question is asked and it deserves a serious answer. Answers based on independent and peer reviewed studies are sought by the committee charged with fact finding. But, the industry response is spurious and misleading. The answer does not address the question. It states that the turbines will be located so as to produce sound levels of 45 dBA. The tone and context imply that 45 dBA is fully compatible with the quiet rural community where they plan to host the WTi. No acknowledgement is made of the dramatic change that will occur for near-by families when a WTi is producing 45 dBA outside their home with the potential for it being 24 hours a day, 7 days a week, and 365 days a year.

No mention is made of how the sounds from the WTi will raise evening and night time background sound levels from existing background levels from the traditional range of 20 dBA to 30 dBA up to 45 dBA once the wind project is operating on a regular basis. There is no disclosure of the considerable low frequency content to the WTi sound; in fact, there are often

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2 AEI is a 501(c)3 non-profit organization based in Santa Fe, New Mexico, USA. The article is available at http://www.acousticecology.org/srwind.html

3 Study review available at: http://www.berr.gov.uk/files/file35592.pdf

claims to the contrary. Yet, modern home construction techniques used for most wood frame homes result in walls and roofs that cannot block WTi low frequencies from penetrating into the interior.

But, from what information the industry has been willing to make public, it appears that none of this prior experience has been applied to the projects in the U.S. Instead, what has been observed of their actions in the U.S. shows WTi project developers and their supporters making claims that wind turbines will not be a noise 'problem' to near-by residents. That the turbines will be "as 'quiet' as a person talking outside the window" of the near-by homes or "no noisier than a refrigerator..."are claims often heard. This ignores the question of just how many people want someone talking outside their bedroom window all night long or wish to sleep with a refrigerator alongside their bed?

A typical WTi developer's response to a question raised by a community committee about noise and health is the following:

> **Q: 19. What sound standards will EcoEnergy ensure that the turbines will be within, based on the setbacks EcoEnergy plans to implement, and what scientific and peer reviewed data do you have to ensure and support there will be no health and safety issues to persons within your setbacks?**
>
> **Answer:** As mentioned, turbines are sited to have maximum sound level of 45dBA. These sound levels are well below levels causing physical harm. Medical books on sound indicate sound levels above 80-90dBA cause physical (health) effects. The possible effects to a person's health due to "annoyance" are impossible to study in a scientific way, as these are often mostly psychosomatic, and are not caused by wind turbines as much as the individuals obsession with a new item in their environment.
>
> **From EcoEnergy's "Response to the Town of Union Health & Safety Research Questionnaire"**
> By Curt Bjurlin, M.S., Wes Slaymaker, P.E., Rick Gungel, P.E., EcoEnergy, L.L.C., submitted to Town of Union, Wisconsin and Mr. Kendall Schneider, on behalf of the Town of Union

There is no mention of the nighttime sound level recommendations set by the World Health Organization (WHO) in their documents on Community Noise or their "Report on the third meeting on night noise guidelines." In those documents WHO recommends that **sound levels during nighttime and late evening hours should be less than 30 dBA during sleeping periods to protect children's health.** They noted that a child's autonomous nervous system is 10 to 15 dB more sensitive to noise than adults. Even for adults, health effects are first noted in some studies when the sound levels exceed 32 dBA L_{max}. These levels are 10-20 dBA lower than the sound levels needed to cause awakening.

For sounds that contain a strong low frequency component, which is typical of wind turbines, WHO says that the limits may need to be even lower than 30 dBA to avoid health risks. Further, they recommend that the criteria use dBC frequency weighting instead of dBA for sources with low frequency content. When sound levels are 45 dBA outside a home, the interior sound levels must be less than 30 dBA in the sleeping areas to avoid sleep disturbance. This is because the low frequency content of the WTi can penetrate the home's walls and roof with very little low frequency noise reduction. An example demonstrating how WTi sound is affected by walls and windows is provided later in this document.

The wind turbine developers also fail to disclose that the International Standards Organization (ISO) in ISO 1996-1971 recommends 25 dBA as the maximum night-time limit for rural communities. As can be seen in the table below sound levels of 40 dBA and above are only appropriate in suburban communities during the day and urban communities during day and night. There are no communities where 45 dBA is considered acceptable at night.

ISO 1996-1971 Recommendations for Community Noise Limits			
District Type	Daytime Limit	Evening Limit 7-11pm	Night Limit 11pm-7am
Rural	35dB	30dB	25dB
Suburban	40dB	35dB	30dB
Urban residential	45dB	40dB	35dB
Urban mixed	50dB	45db	40dB

Even more egregious, the wind industry makes claims like *"These sound levels are well below levels causing physical harm. Medical books on sound indicate sound levels above 80-90dBA cause physical (health) effects."* First of all, concern about sound levels in the 80-90 dBA range is for hearing health, (your ears) and not the health related issues of sleep disturbance and other causative factors associated with prolonged exposure to low levels of noise. This type of response is a non-answer. It is a conscious attempt to mislead while giving the appearance of providing a legitimate response.

Further, the statement: *"The possible effects to a person's health due to "annoyance" are impossible to study in a scientific way, as these are often mostly psychosomatic, and are not caused by wind turbines as much as the individuals obsession with a new item in their environment"* is both inaccurate and misleading. It ignores the work of researchers like Drs. Eja Pedersen, Amanda Harry, Robin Phipps, and the numerous medical research studies summarized in the work of Frey and Hadden to name just a few. These studies, in addition to the work here in the U.S. by Dr. Pierpont, belie the claims of the wind industry. This 'oversight' of published studies is so blatant as to make some interpret their claim of 'no medical research' as a conscious decision to not look for it. If they looked they would find there are numerous studies by qualified medical researchers that contradict their claim.

Compounding these unfounded and misleading claims to the questions raised by the community's committee members, wind industry advocates who have little or no medical qualifications make statements outside of their area of competence. They label complaints of health effects as 'psychosomatic' in a pejorative manner that implies the complaints can be discounted because they are not really "medical" conditions. These responses cannot be considered as based in fact. They ignore the work of many researchers, including health organizations like WHO on the effect of sounds during nighttime hours that result in sleep disturbance and other disorders that cause physical, not just psychological pathologies.[4 5] Many people find it difficult to articulate what has changed. They know that something is different and they may express it as feeling uncomfortable, uneasy, and sleepless or some other symptom. Yet, they often cannot explain why this is happening.

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[4] WHO European Centre for Environment and Health, Bonn Office, "Report on the third meeting on night noise guidelines," April 2005

[5] According to Online Etymology Dictionary, Psychosomatic means: "pertaining to the relation between mind and body," ... Applied from 1938 to physical disorders with psychological causes."

The attempt to make light of the well established physical effects of nighttime sounds from WTi located too close to homes by labeling them as 'psychosomatic' is the only response the wind industry offers to a question about real health risks. To many, the constant denial by the wind industry and its promoters about health risks is a 'red flag' that something is amiss.

Industry representatives on State level governmental committees have worked to establish sound limits and setbacks that are even more lenient. In Michigan, for example, the Governor's State Task Force recommended in its "Siting Guidelines for Wind Energy Systems" that the limits be set at 55 dBA or L_{90} +5 dBA, whichever is <u>**higher**</u>. In Wisconsin, the State Task Force has recommended 50 dBA.

Who are on these Task Forces? When Wisconsin's Town of Union wind turbine committee made an open records request to find out what scientific basis there was for the sound levels and setbacks in the state's draft model ordinance it was revealed that no scientific or medical data was used at all. Review of the meeting minutes provided under that request showed that the limits had been set by Task Force members representing the wind industry. [6]

Why have State level committees and/or task forces drafted ordinances with upper limits of 50 dBA or higher instead of the much lower limits applied to similar projects in other countries? Where do they find the support for claims that locating 400 foot tall WTi as close as 1000 feet (or less) to non-participating properties will not create noise disturbances or other risks? How can they make the claims in the face of a legacy of complaints from people living near existing wind turbine developments? Why so close? [7] Whose interest is being served? [7]

It is disappointing that the studies that are needed have not been done by the wind industry or any of the other people eager to satisfy our federal and state government's unbridled enthusiasm for wind energy. This type of work has been delegated by the wind industry and its supporters to private individuals and researchers who are working to understand what differences in siting, weather, and operational modes result in the 'failures.' When people in a community complain about an existing wind project doesn't this create a serious public relations problem for the wind industry? Why is there a sense of denial in its response to these situations?

The burden of the small percentage of failures is placed on the people who are being forced to live with conditions they find annoying at best and intolerable at its worst. Many of these people feel that they have had no part to the decisions that created these conditions. Often, they were members of a citizen's group that tried to forewarn their local government about the

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6 Lawton, Catharine M., Letter to Wisconsin's "Guidelines and Model Ordinances Ad Hoc Subcommittee of the Wisconsin Wind Power Siting Collaborative" in Response to Paul Helgeson's 9/20/00 "Wisconsin Wind Ordinance Egroups E-Mail Message," Sept. 20, 2000, a Public Record obtained through Open Meetings Act request by the Town of Union, Wisconsin, Large Wind Turbine Citizens Committee.

7 It is worth noting that the 2007-06-29 version of the Vestas Mechanical Operating and Maintenance Manual for the model V90 – 3.0 MW VCRS 60 Hz turbine includes this warning for technicians and operators:

> **2. Stay and Traffic by the Turbine**
>
> <u>Do not stay within a radius of 400m (1300ft) from the turbine unless it is necessary</u>. If you have to inspect an operating turbine from the ground, do not stay under the rotor plane but observe the rotor from the front. Make sure that children do not stay by or play nearby the turbine. ....

possibility that the wind project would not be compatible with their community. On top of this individualized burden they are asked, like the rest of us, to bear the increased costs for electricity, subsidies, and taxes that result from the government incentives to entice investments in WTi developments.

This is why the two studies in this document are so important. They are not the product of a well funded research project by a major research group, but are instead the personal work of private individuals with expertise in their respective fields, but limited in both funds and access to the internal data of the wind industry.

Both studies are based on solid foundations and their authors are experienced in their respective fields. But, these studies are of necessity limited by the barriers that prevent access to internal data and the time and funds to conduct the research while trying to conduct their normal business activities. Those who may not like the results of the studies will work hard to find flaws to use in an attempt to discredit them, but those are the same people and organizations that have not been pro-active by funding the appropriate independent research or providing access to data that is now claimed as 'trade-secrets' by the industry. Whether the attempts to discredit are to claim that the research is too limited or that the information upon which the conclusions are drawn are limited or some other argument the truth is that the wind industry should have done this work in an open, public manner using research groups that are both qualified and totally independent. <u>That</u> is the real problem.

There is much that can be done even in the face of limited resources. For example, there may be questions about whether wind turbines produce low frequency or infra-sound emissions or not. But, one does not have to know that there are high levels of low frequency or infrasound to develop criteria that will protect against excessive levels just in case they are part of the WTi sound emissions. One does not have to know what the mechanism is for pathology, if one knows that moving away from wind turbines allows the pathologies to stabilize or reverse then it is best to move away. Knowing what we wish to avoid is often enough to justify establishing rules and guidelines that protect a community <u>just in case those problems do exist</u>.

These are early studies that should lead to more thorough studies, with proper funding. If this work had been done by the wind industry prior to generating the government enthusiasm for their product with claims of compatibility with land-use in rural communities then people like Dr. Pierpont and the authors of this article would not be doing it on their behalf. We sincerely hope that our work will lead to a higher level of interest in seeking the answer to the question of why some WTi projects do not result in acceptance by people living near them in the host communities.

No new industrial process should be imposed on an unsuspecting public without having been thoroughly, publicly, and independently studied beforehand. Only after such studies show that industrial WTi projects do not introduce risks to the health or safety of the target communities should they be permitted to proceed. If the studies show there are risks, then the next step is to determine what is needed to prevent them.

Until such work is done and accepted by independent reviewers, no WTi projects should be permitted using taxpayer funds without stringent rules for noise and other risk factors. In the absence of such work, it is both prudent and necessary to error on the side of caution regarding public health and safety including stringent standards limiting noise and other risk factors until more and better information becomes available.

Options for Siting Criteria

We started our research into guidelines for proper siting by reviewing the various guidelines used in other countries to limit WTi sound emissions. A recent compendium of many of these standards was presented in the report: "Wind Turbine Facilities Noise Issues"[8]. We found some common ground in many of them. Some like Germany set explicit not-to-exceed sound level limits like 40 dBA nighttime in residential areas and 35 dBA nighttime in rural and other noise sensitive areas. Other countries used the existing background sound levels for each community as the basis for establishing the sound level limits for the WES project. This second method has the advantage of adjusting the allowable limits for various background soundscapes. It makes use of a standard method for assessing background sound levels by measuring over a specified period of observation to determine the sound level exceeded 90% of the time (L_{90}) during the night. The night is important because it is the most likely time for sleep disturbance. Then, using the background sound level as the base the WES project is allowed to increase it by 5 dBA. It is this second method (L_{90} + 5 dBA) that we adopted for the criteria in this document. It has the advantage of adjusting the criteria for each community without the need for tables of allowable limits for different community types. We also focused only on the nighttime criteria. This is because the WES will operate 24 hours a day and the nighttime limits will be the controlling limits whether or not there are other limits for daytime.

Since many rural communities are very quiet it is possible that some will have L_{90} values of 25 dBA or lower. This may seem extreme when compared to limits usually imposed on other sources of community noise. But, wind turbine sounds are not comparable to the more common noise sources of vehicles, aircraft, rail and industry. Several studies[9] have shown that annoyance to wind turbine sounds begins at levels as low as 30 dBA. This is especially true in quiet rural communities that have not had previous experience with industrial noise sources. This increased sensitivity may be a result of the periodic 'whoosh'

> The World Health Organization recognizes the special place of low frequency noise as an environmental problem. Its publication "Community Noise" (Berglund et al., 2000) makes a number of references to low frequency noise, some of which are as follows:
>
> - "It should be noted that low frequency noise... can disturb rest and sleep even at low sound levels.
> - For noise with a large proportion of low frequency sounds a still lower guideline (than 30dBA) is recommended.
> - When prominent low frequency components are present, noise measures based on A-weighting are inappropriate.
> - Since A-weighting underestimates the sound pressure level of noise with low frequency components, a better assessment of health effects would be to use C-weighting.
> - It should be noted that a large proportion of low frequency components in a noise may increase considerably the adverse effects on health."
>
> WHO also states: "The evidence on low frequency noise is sufficiently strong to warrant immediate concern."

[8] Ramakrishnan, Ph. D., P. Eng., Ramani, "Wind Turbine Facilities Noise Issues" Dec. 2007 Prepared for the Ontario Ministry of Environment.

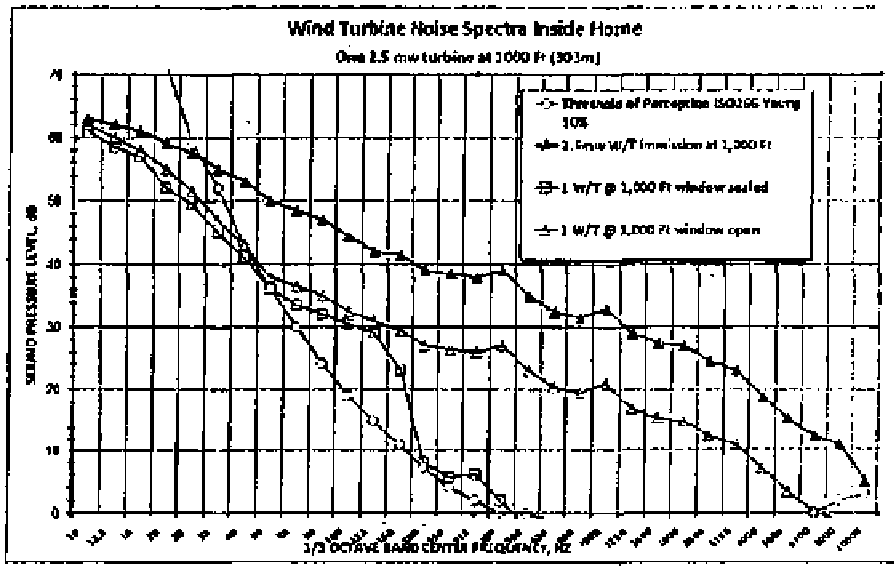
[9] Eja Pedersen, "Human response to wind turbine noise – Perception, annoyance and moderating factors, Occupational and Environmental Medicine," The Sahlgrenska Academy, Gotenborg 2007 and the more recent work "Wind Farm Perception".

from the blades against the quiet rural soundscape or it may be more complex. But, it is a legitimate response to wind turbine sound based on solid peer reviewed research.

In the adjacent text box are a series of observations and recommendations of the World Health organization (WHO) supporting the need for stricter limits when there is substantial low frequency content in the outdoor sound. Our review of other studies plus our own studies has demonstrated that wind turbine sound includes considerable low frequency content. We elected to include a dBC limit in our guidelines to address the WHO recommendation that when low frequency sound may be present criteria based on measurements using a C-weighting filter on the sound level meter (dBC) are needed in addition to any dBA criteria.

When low frequency sound is present outside homes and other occupied structures; it is often more likely to be an indoor problem than an outdoor one. This is very true for wind turbine sounds.

To demonstrate the effects of outdoor low frequency content from wind turbines we prepared the figures below showing the effect of a single turbine (propagation model based on sound power level test data) at 1000 feet and ten (10) turbines at one (1) mile. The graphs each show the outdoor sound pressure levels predicted for the distance of 1000 feet or one mile as the upper graph line. There is also a curve that shows the threshold of human perception for sounds at each 1/3 octave band center. When the graphs representing wind turbine sound have data points above this curve the sounds will be perceptible to at least 10% of the population. In addition to the top graph line representing the sounds outside the home there are two other graph lines for the sounds inside the home[10]. One graph represents the condition of no open windows and the other represents one open window. Note how the two graph lines for the inside conditions are significantly higher in amplitude than the curve representing the threshold of perception. Even with the windows closed the sound pressure levels in the 63 Hz to 200 Hz octave bands still exceed the perception curve, in many cases by more than 10 dB. When comparing the dBC values the difference between inside sounds and outside is much less. The maximum difference in this example is only 7 dBC and that is for the situation with windows closed. With windows open the sound inside the home would be 56 dBC while it is 61 dBC outside; a difference of only

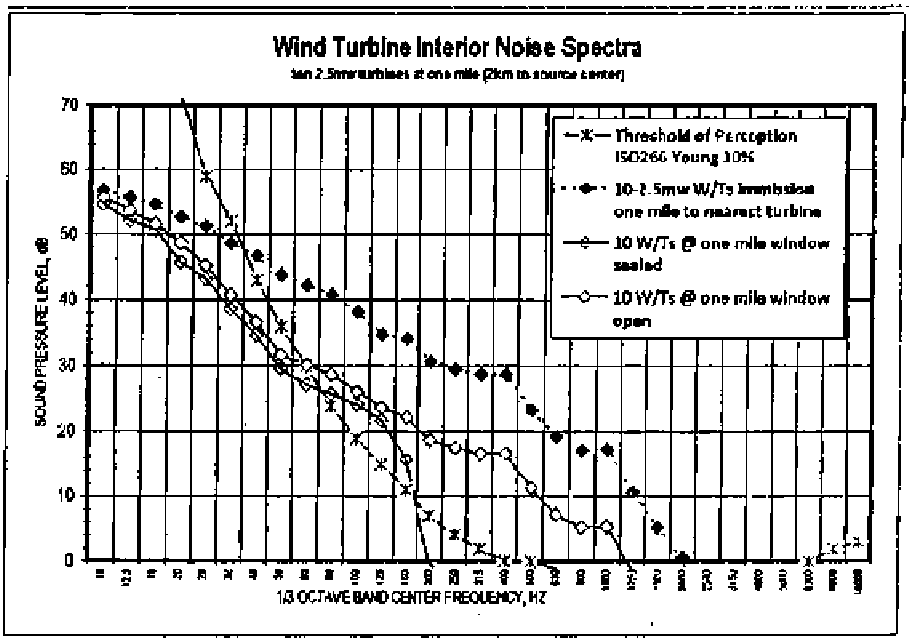


[10] The typical wood stud exterior used in modern home construction is vinyl siding over 1/2 inch OSB or rigid fiberglass board applied to 2 X 4 studs with the stud space filled with thermal and 1/2 inch gypsum board applied on the exposed interior side. This has a mass of about 3-4 lbs/sq ft and low 26 STC.

5 dBC[11,12,13]. If we looked only at dBA it would appear that the home's walls and roof provide a reduction of 15 dBA or more. But, that is misleading. It incorrectly ignores the effects of low frequency sound. Relying on dBA alone will not work for community noise criteria. It is the low frequency phenomena associated with WTi emissions that makes the dBC tests an important part of the proposed criteria.

We applied the façade sound isolation data from the Canada Research Council to the 2.5 MW wind turbine example used in our Noise-Con 2008 paper (next section). With just one turbine at 1,000 feet there is a significant amount of low frequency noise above hearing threshold inside a home near an exterior wall without windows or very well sealed windows. Note the perceptible sound between 50 and 200 Hz with a wall resonance frequency at 125 Hz (2 X 4 studs on 16 inch centers) for the windows closed condition. This would be perceived as a constant low rumble which would be present in the homes whenever the turbines are operating.

We next increased the number of 2.5 Mw turbines from one to ten and moved the receiver one mile from the closest turbine. We assumed the acoustic center for the ten turbines to be 2km (1-1/4 miles) from the receiver. These results are in the figure below. For air absorption we assumed 20°C and 50% RH. Ground reflection had already been accounted for in the earlier 2.5 Mw 1,000' calculations of SPL from the sound power data (L_w).. We used only simple inverse-square propagation. We were surprised to find that the one mile low frequency results are only 6.3 dB below the 1,000 foot one turbine example.



This may explain why some residents as far as two (2) miles from a wind farm find the wind turbines sounds highly annoying.

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[11] The basis for these predictions includes reports on aircraft sound insulation for dwellings and façade sound isolation data from the Canada Research Council.

[12] "On the sound insulation of wood stud exterior walls" by J. S. Bradley and J. S. Birta, institute for Research in Construction, National Research Council, Montreal Road, Ottawa K1A 0R6, Canada, published: J.Acoust. Soc. Am. 110 (6), December 2001

[13] Dan Hoffmeyer, Birger Plovsing: "Low Frequency Noise from Large Wind Turbines, Measurements of Sound Insulation of Facades." Journal no. AV 1097/08, Client: Danish Energy Authority, Amaliegade 44, 1256 Copenhagen K

The next section of this article presents the Noise-Con 2008 paper with some recent revisions. It is therefore more current than the version published in the proceedings.

Dearborn, Michigan

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Simple guidelines for siting wind turbines to prevent health risks[14]

By:

George W. Kamperman, INCE Bd. Cert. Emeritus
Kamperman Associates, Inc.
george@kamperman.com

Richard R. James, INCE
E-Coustic Solutions
rickjames@e-coustic.com

Revision: 1.0

Industrial scale wind turbines are a familiar part of the landscape in Europe, U.K. and other parts of the world. In the U.S., however, similar industrial scale wind energy developments are just beginning operation. The presence of industrial wind projects will increase dramatically over the next few years given the push by the Federal and state governments to promote renewable energy sources through tax incentives and other forms of economic and political support. States and local governments in the U.S. are promoting what appear to be lenient rules for how industrial wind farms can be located in communities, which are predominantly rural and often very quiet. Studies already completed and currently in progress describe significant health effects associated with living in the vicinity of industrial grade wind turbines. This paper reviews sound studies conducted by consultants for governments, the wind turbine owner, or the local residents for a number of sites with known health or annoyance problems. The purpose is to determine if a set of simple guidelines using dBA and dBC sound levels can serve as the 'safe' siting guidelines. Findings of the review and recommendations for sound limits will be presented. A discussion of how the proposed limits would have affected the existing sites where people have demonstrated pathologies apparently related to wind turbine sound will also be presented.

Background

A relatively new source of community noise is spreading rapidly across the rural U.S. countryside. Industrial grade wind turbines, a common sight in many European countries, are now being promoted by Federal and state governments as the way to minimize coal powered

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electrical energy and its effects on global warming. But, the initial developments using the newer 1.5 to 3 MWatt wind turbines here in the U.S. has also led to numerous complaints from residents who find themselves no longer in the quiet rural communities they were living in before the wind turbine developments went on-line. Questions have been raised about whether the current siting guidelines being used in the U.S. are sufficiently protective for the people living closest to the developments. Research being conducted into the health issues using data from established wind turbine developments is beginning to appear that supports the possibility there is a basis for the health concerns. Other research into the computer modeling and other methods used for determining the layout of the industrial wind turbine developments and the distances from residents in the adjacent communities are showing that the output of the models should not be considered accurate enough to be used as the sole basis for making the siting decisions.

The authors have reviewed a number of noise studies conducted in response to community complaints for wind energy systems sited in Europe, Canada, and the U.S. to determine if additional criteria are needed for establishing safe limits for industrial wind turbine sound immissions in rural communities. In several cases, the residents who filed the complaints have been included in studies by medical researchers who are investigating the potential health risks associated with living near industrial grade wind turbines 365 days a year. These studies were also reviewed by the authors to help in identifying what factors need to be considered in setting criteria for 'safe' sound limits at receiving properties. Due to concerns about medical privacy, details of these studies are not discussed in this paper. Current standards used in the U.S. and in most other parts of the world rely on not-to-exceed dBA sound levels, such as 50 dBA, or on not-to-exceed limits based on the pre-construction background sound level plus an adder (e.g. L_{90A} + 5 dBA).

Our review covered the community noise studies performed in response to complaints, research on health issues related to wind turbine noise, critiques of noise studies performed by consultants working for the wind developer, and research/technical papers on wind turbine sound immissions and related topics. The papers are listed in Tables 1-4.

Table 1-List of Studies Related to Complaints

Resource Systems Engineering, Sound Level Study - Ambient & Operations Sound Level Monitoring, Maine Department of Environmental Protection Order No. L-21635-26-A-N, June 2007
ESS Group, Inc., Draft Environmental Impact Statement For The Dutch Hill Wind Power Project - Town of Cohocton, NY, November 2006
David M. Hessler, Environmental Sound Survey and Noise Impact Assessment - Noble Wethersfield Wind park - Towns of Wethersfield and Eagle NY For: Noble Environmental Power, LLC January 2007
George Hessler, "Report Number 101006-1, Noise Assessment Jordanville Wind Power Project," October 2006
HGC Engineering, "Environmental Noise Assessment Pubnico Point Wind Farm, Nova Scotia, Natural Resources Canada Contract NRCAN-06-0046," August 23, 2006
John I. Walker, Sound Quality Monitoring, East Point, Prince Edward Island" by Jacques Whitford, Consultants for Prince Edward Island Energy Corporation, May 28, 2007

Table 2- List of Studies related to Health

Nina Pierpont, "Wind Turbine Syndrome – Abstract" from draft article and personal conversations. www.ninapierpont.com
Nina Pierpont, "Letter from Dr. Pierpont to a resident of Ontario, Canada, re: Wind Turbine Syndrome," Autumn 2007
Amanda Harry, "Wind Turbine Noise and Health" (2007)
Barbara J. Frey and Peter J. Hadden, "Noise Radiation from Wind Turbines Installed Near Homes, Effects on Health" (2007)
Eja Pedersen, "Human response to wind turbine noise - Perception, annoyance and moderating factors, Occupational and Environmental Medicine," The Sahlgrenska Academy, Gotenborg 2007
Robin Phipps, "In the Matter of Moturimu Wind Farm Application, Palmerston North, Australia," March 2007
WHO European Centre for Environment and Health, Bonn Office, "Report on the third meeting on night noise guidelines," April 2005

Table 3-List of Studies that review Siting Impact Statements

Richard H. Bolton, "Evaluation of Environmental Noise Analysis for 'Jordanville Wind Power Project,'" December 14, 2006 Rev 3.
Clifford P. Schneider, "Accuracy of Model Predictions and the Effects of Atmospheric Stability on Wind Turbine Noise at the Maple Ridge Wind Power Facility," Lowville, NY - 2007

Table 4-List of Research and Technical papers included in review process

Anthony L. Rogers, James F. Manwell, Sally Wright, "Wind Turbine Acoustic Noise," Renewable Energy Research Laboratory, Dept. of ME and IE, U of Mass, Amherst, amended June 2006
ISO. 1996. Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation. International Organization of Standardization. ISO 9613-2. p. 18.
G.P. van den Berg, "The Sounds of High Winds – the effect of atmospheric stability on wind turbine sound and microphone noise," Ph.D. thesis, 2006
Fritz van den Berg, "Wind Profiles over Complex Terrain," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
William K. G. Palmer, "Uncloaking the Nature of Wind Turbines-Using the Science of Meteorology," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
Soren Vase Legarth, "Auralization and Assessment of Annoyance from Wind Turbines," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007

Julian T. and Jane Davis, "Living with aerodynamic modulation, low frequency vibration and sleep deprivation - how wind turbines inappropriately placed can act collectively and destroy rural quietitude," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
James D. Barnes, "A Variety of Wind Turbine Noise Regulations in the United States - 2007," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
M. Schwartz and D. Elliott, Wind Shear Characteristics at Central Plains Tall Towers, NREL 2006
IEC 61400 "Wind turbine generator systems, Part 11: Acoustic noise measurement techniques," rev:2002

Discussion

After reviewing the materials in the tables; we have arrived at our current understanding of wind turbine noise and its impact on the host community and its residents. The review showed that some residents living as far as 3 km (two (2) miles) from a wind farm complain of sleep disturbance from the noise. Many residents living one-tenth this distance (300 m. or 1000 feet) from a wind farm are experiencing major sleep disruption and other serious medical problems from nighttime wind turbine noise. The peculiar acoustic characteristics of wind turbine noise immissions cause the sounds heard at the receiving properties to be more annoying and troublesome than the more familiar noise from traffic and industrial factories. Limits used for these other community noise sources do not appear to be appropriate for siting industrial wind turbines. The residents who are annoyed by wind turbine noise complain of the approximately one (1) second repetitive swoosh-boom-swoosh-boom sound of the turbine blades and "low frequency" noise. It is not apparent to these authors whether the complaints that refer to "low frequency" noise are about the audible low frequency part of the swoosh-boom sound, the one hertz amplitude modulation of the swoosh-boom sound, or some combination of both acoustic phenomena.

To assist in understanding the issues at hand, the authors developed the 'conceptual' graph for industrial wind turbine sound shown in Figure 1. This graph shows the data from one of the complaint sites plotted against the sound immission spectra for a modern 2.5 MWatt wind turbine; Young's threshold of perception for the 10% most sensitive population (ISO 0266); and a spectrum obtained for a rural community during a three hour, 20 minute test from 11:45 pm until 3:05 am on a windless June evening in near Ubly, Michigan a quiet rural community located in central Huron County. (Also called: Michigan's Thumb.) It is worth noting that this rural community demonstrates how quiet a rural community can be when located at a distance from industry, highways, and airport related noise emitters.

During our review we posed a number of questions to ourselves related to what we were learning. The questions (italics) and our answers are:

Do National or International or local community Noise Standards for siting wind turbines near dwellings address the low frequency portion of the wind turbine's sound immissions?[15] No! State and Local governments are in the process of establishing wind farm noise limits and/or wind turbine

[15] Emissions refer to acoustic energy from the 'viewpoint' of the sound emitter, while immissions refer to acoustic energy from the viewpoint of the receiver.

setbacks from nearby residents, but the standards incorrectly presume that limits based on dBA levels are sufficient to protect the residents.

Do wind farm developers have noise limit criteria and/or wind turbine setback criteria that apply to nearby residents? Yes! But the Wind Industry recommended residential wind turbine noise levels (typically 50-55 dBA) are too high for the quiet nature of the rural communities and may be unsafe for the nearest residents. An additional concern is that some of the methods for implementing pre-construction computer models may predict sound levels that are too low. These two factors combined can lead to post-construction complaints and health risks.

Are all residents living near wind farms equally affected by wind turbine noise? No, children, people with pre-existing medical conditions, especially sleep disorders, and the elderly are generally the most susceptible. Some people are unaffected while some nearby neighbors develop serious health effects caused by exposure to the same wind turbine noise.

How does wind turbine noise impact nearby residents? Initially, the most common problem is chronic sleep deprivation during nighttime. According to the medical research documents, this may develop into far more serious physical and psychological problems

What are the technical options for reducing wind turbine noise immission at residences? There are only two options: 1) increase the distance between source and receiver, and/or 2) reduce the source sound power immission. Either solution is incompatible with the objective of the wind farm developer to maximize the wind power electrical generation within the land available.

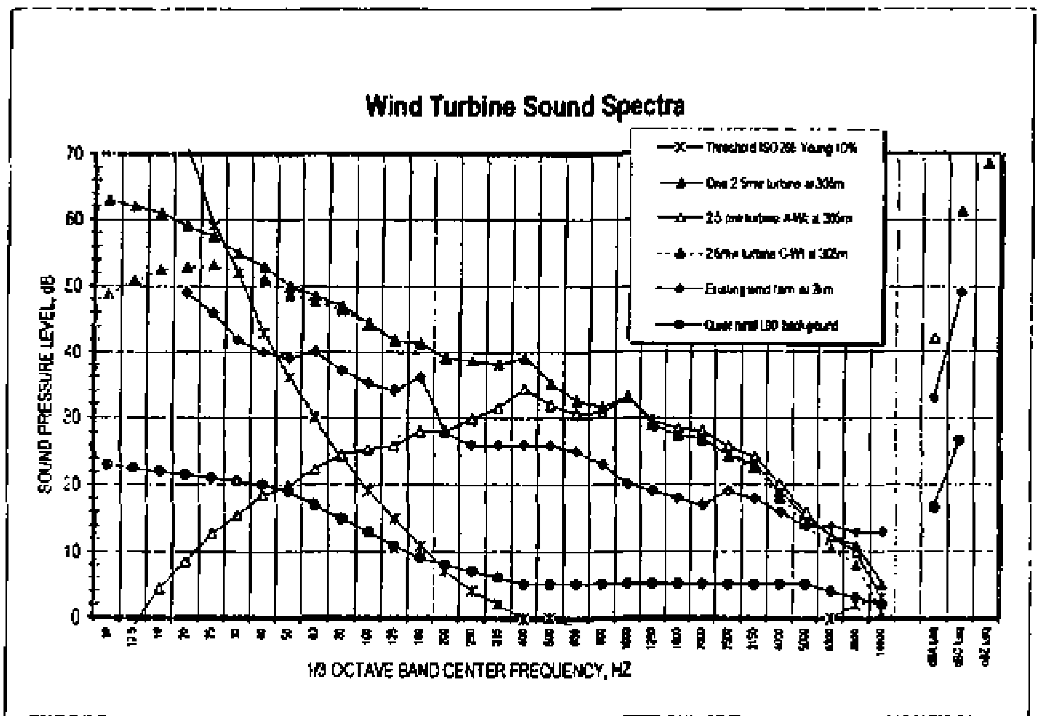


Figure 1-Generalized Sound Spectra vs. perception and rural community L_{90A} background 1/3 octave SPL

Is wind turbine noise at a residence much more annoying than traffic noise? Yes, researchers have found that "Wind turbine noise was perceived by about 85% of the respondents even when the calculated A-weighted SPL were as low as 35.0-37.5 dB. This could be due to the presence of amplitude modulation in the noise, making it easy to detect and difficult to mask by ambient noise." [JASA 116(6), December 2004, pgs 3460-3470, "Perception and annoyance due to wind turbine noise-a dose-relationship" Eja Pedersen and Kerstin Persson Waye, Dept of Environmental Medicine, Goteborg University, Sweden]

Why do wind turbine noise immissions of only 35 dBA disturb sleep at night? This issue is now being studied by the medical profession. The affected residents complain of the middle to high frequency swooshing sounds of the rotating turbine blades at a constant repetitive rate of about 1 hertz plus low frequency noise. The amplitude modulation of the swooshing sound changes continuously. The short time interval between the blades's swooshing sounds described by residents as sometimes having a thump or low frequency banging sound that varies in amplitude up to 10 dBA. This may be a result of phase changes between turbine emissions, turbulence, or an operational mode. The assumptions about wall and window attenuation being 15 dBA or more may not be sufficiently protective considering the relatively high amplitude of the wind turbine's low frequency immission spectra.

What are the typical wind farm noise immission criteria or standards? Limits are not consistent and may vary even within a particular country. Example criteria include: Australia-the highest of 35 dBA or L_{90} + 5 dBA, Denmark-40 dBA, France L_{90} + 3 (night) and L_{90} + 5 (day), Germany-40 dBA, Holland-40 dBA, United Kingdom-40 dBA (day) and 43 dBA (night) or L_{90} + 5 dBA, Illinois-Octave frequency band limits: About 50 dBA (day) and about 46 dBA (night), Wisconsin-50 dBA and Michigan-55 dBA.

What is a reasonable wind farm sound immission limit to protect the health of residences? We are proposing an immission limit of 35 dBA or L_{90A} + 5 dBA whichever are lower and also C-weighted criteria to address the impacted resident's complaints of wind turbine low frequency noise: For the proposed criteria the dBC sound level at a receiving property shall not exceed L_{90A} + 20dB. In other words, the dBC operating immission limit shall not be more than 20 dB above the measured dBA (L_{90A}) pre-construction nighttime background sound level. A maximum not-to-exceed limit of 50 dBC and 55 dBC is also proposed.

Why should the dBC immission limit not be permitted to be more than 20 dB above the background measured L_{90A}? The World Health Organization and others have determined a sound emitter's noise that results in a difference between the dBC and dBA value greater than 20 dB will be an annoying low frequency issue.

Is not L_{90A} the minimum dBA background noise level? This is correct, but it is very important to establish the statistical average background noise environment outside a potentially impacted residence during the quietest (10 pm to 4 am) sleeping hours of the night. This nighttime sleep disturbance has generated the majority of the wind farm noise complaints throughout the world. The basis for a community's wind turbine sound immission limits would be the minimum 10 minute nighttime L_{90A} plus 5 dB for the time period of 10 pm to 7 am. This would become the Nighttime Immission Limits for the proposed wind farm. This can be accomplished with one or several 10 minute measurements during any night when the atmosphere is classified stable with a light wind from the area of the proposed wind farm. The Daytime Limits (7 am to 7 pm) could be set 10 dB above the minimum nighttime L_{90A} measured noise, but the nighttime criteria will always be the limiting sound levels.

A nearby wind farm meeting these noise immission criteria will be clearly audible to the residents occasionally during nighttime and daytime. Compliance with this noise standard would be determined by repeating the initial nighttime minimum nighttime L_{90A} tests and adding the dBC (L_{eqC}) noise measurement with the turbines on and off. If the nighttime background noise level (turbines off) was found to be slightly higher than the measured background prior to the wind farm installation, then the results with the turbines on must be corrected to determine compliance with the pre-turbine established sound limits.

The common method used for establishing the background sound level at a proposed wind farm used in many of the studies in Table 1 was to use unattended noise monitors to record hundreds of ten (10) minute measurements to obtain a statistically significant sample over varying wind conditions or a period of weeks. The measured results for daytime and nighttime are combined to determine the statically average wind noise as a function of wind velocity measured at a height of ten (10) meters. This provides an enormous amount of data but the results have little relationship to the wind turbine sound immission or turbine noise impact in nearby residents. The purpose of this exhaustive exercise often only demonstrates how much noise is generated by the wind. In some cases it appears that the data is used to 'prove' that the wind noise masks the turbine's sound immissions.

The most glaring fault with this argument is shown during the frequent nighttime conditions with a stable atmosphere when the wind turbines generate the maximum electricity and noise while the wind at ground level is calm and the background noise level is low. This is the condition of maximum turbine noise impact on nearby residents. It is the condition which most directly causes chronic sleep disruption. Furthermore, this methodology is usually faulty, as much of the wind noise measured by unattended sound monitors is the wind noise generated at the microphone windscreen resulting in totally erroneous results. (See studies in Table 3, esp. Van den Berg)

Are there additional noise data to be recorded for a pre-wind turbine noise survey near selected dwellings? Yes, The measuring sound level meter(s) need to be programmed to include measurement of L_{eqA}, L_{10A}, L_{eq90A} and L_{eqC}, L_{10C}, L_{eq90C} plus start time & date for each 10 minute sample. These results will be utilized to help validate the L_{90} data. For example, on a quiet night one might expect L_{10} and L_{90} or L_{eq} to show similar results within 5 to 10 dBA and 10 to 15 dBC. On a windy night or day the difference between L_{10} and L_{90} may be more than 20 dBA and 30 dBC. There is also a need to obtain a ten minute time averaged one-third octave band analysis over the frequency range from 6.3 Hz to 10k Hz. The frequency analysis is very helpful for identifying and correcting for extraneous sounds such as interfering insect noise. A standard averaging sound level meter has the capability to perform all of the above acoustic measurements simultaneously and store the results internally. There is a requirement for measurement of the wind velocity near the sound measurement microphone continuously throughout each ten (10) minute recorded noise sample. The ten (10) minute maximum wind speed near the microphone shall not exceed 2 m/s (4.5 mph) and the maximum wind speed for operational tests shall not exceed 4 m/s (9 mph). It is strongly recommended that observed measurements be used for these tests.

Is there a need to record weather data during the background noise recording survey? One weather monitor is required at the proposed wind farm on the side nearest the residents. The weather station sensors are at standard ten (10) meter height above ground. It is critical the weather be recorded every ten (10) minutes synchronized with the clocks in the sound level recorders without ambiguity in the start and end time of each ten (10) minute period. The weather station should record wind speed and direction, temperature, humidity and rain.

Why do Canada and some other countries base the permitted wind turbine noise immission limits on the operational wind velocity at the 10m height wind speed instead of a maximum dBA or L_{90} + 5 dBA immission level? First, it appears that the wind turbine industry will take advantage of every opportunity to elevate the maximum permitted noise immission level to reduce the setback distance from the nearby dwellings. Including wind as a masking source in the criteria is one method for elevating the permissible limits. Indeed the background noise level does increase with surface wind speed. When it does occur, it can be argued that the increased wind noise provides some masking of the wind farm turbine noise emission. However, in the middle of the night when the atmosphere is defined as stable (no vertical flow from surface heat radiation) the layers of the lower atmosphere can separate and permit wind velocities at the turbine hubs to be 2 to 4 times the wind velocity at the 10m high wind monitor but remain near calm at ground level. The result is the wind turbines can be operating at or close to full capacity while it is very quiet outside the nearby dwellings.

This is the heart of the wind turbine noise problem for residents within 3 km (approx. two miles) of a wind farm. When the turbines are producing the sound from operation it is quietest outside the surrounding homes. The PhD thesis of P.G. van den Berg "The Sounds of High Winds" is very enlightening on this issue. See also the letter by John Harrison in Ontario "On Wind Turbine Guidelines."

What sound monitor measurements would be needed for enforcement of the wind turbine sound ordinance? A similar sound and wind 10 minute series of measurements would be repeated at the pre-wind farm location nearest the resident registering the wind turbine noise complaint, with and without the operation of the wind turbines. An independent acoustics expert should be retained who reports to the County Board or other responsible governing body. This independent acoustics expert shall be responsible for all the acoustic measurements including instrumentation setup, calibration and interpretation of recorded results. An independent acoustical consultant shall also perform all pre-turbine background noise measurements and interpretation of results to establish the Nighttime (and Daytime if applicable) industrial wind turbine sound immission limits. At present the acoustical consultants are retained by, and work directly for, the wind farm developer.

This presents a serious problem with conflict of interest on the part of the consultant. The wind farm developer would like to show the significant amount of wind noise that is present to mask the sounds of the wind turbine immissions. The wind farm impacted community would like to know that wind turbine noise will be only barely perceptible and then only occasionally during the night or daytime.

Is frequency analysis required either during pre-wind farm background survey or for compliance measurements? Normally one-third octave or narrower band analysis would only be required if there is a complaint of tones immission from the wind farm. Although only standardized dBA and dBC measurements are required to meet the proposed criteria the addition of one-third octave band analysis is often useful to validate the dBA and dBC results.

Proposed Sound Limits

The simple fact that so many residents complain of low frequency noise from wind turbines is clear evidence that the single A-weighted (dBA) noise descriptor used in most jurisdictions for siting turbines is not adequate. The only other simple audio frequency weighting that is standardized and available on sound level meters is the C-weighting or dBC. A standard sound level meter set to measure dBA is increasingly less sensitive to low frequency below 500 Hz (one octave above middle-C). The same sound level meter set to measure dBC is equally sensitive to all frequencies above 32 Hz (lowest note on grand piano). It is well known that dBC readings are more predictive of perceptual loudness than dBA readings if low frequency sounds are significant.

We are proposing to use the commonly accepted dBA criteria that is based on the pre-existing background sound levels plus a 5 dB allowance for the wind turbine's immissions (e.g. L_{90A} +5) for the audible sounds from wind turbines. But, to address the lower frequencies that are not considered in A-weighted measurements we are proposing to add limits based on dBC. The Proposed Sound Limits are presented in the text box at the end of this paper.

For the current industrial grade wind turbines in the 1.5 to 3 MWatt range, the addition of the dBC requirement will result in an increased distance between wind turbines and the nearby residents. For the generalized graphs shown in Figure 1, the distances would need to be increased significantly. This will result in setbacks in the range of 1 km or greater for the current generation of wind turbines if they are to be located in rural areas where the L_{90A} background sound levels are 30 dBA or lower. In areas with higher background sound levels, turbines could be located somewhat closer, but still at a distance greater than the 305 m (1000 ft.) or less which are setbacks commonly seen in U.S. based wind turbine standards set by many states and used for wind turbine developments.

Proposed Wind Turbine Siting Sound Limits

1. Audible Sound Limit

a. No Wind Turbine or group of turbines shall be located so as to cause an exceedance of the pre-construction/operation background sound levels by more than 5 dBA. The background sound levels shall be the L_{90A} sound descriptor measured during a pre-construction noise study during the quietest time of evening or night. All data recording shall be a series of contiguous ten (10) minute measurements. L_{90A} results are valid when L_{10A} results are no more than 10 dBA above L_{90A} for the same time period. Noise sensitive sites are to be selected based on wind development's predicted worst-case sound emissions (in L_{eqA} and L_{eqC}) which are to be provided by the developer.

b. Test sites are to be located along the property line(s) of the receiving non-participating property(s).

c. A 5 dB penalty is applied for tones as defined in IEC 61400-11.

2. Low Frequency Sound Limit

a. The L_{eqC} and L_{90C} sound levels from the wind turbine at the receiving property shall not exceed the lower of either:

1) L_{eqC}-L_{90A} greater than 20 dB outside any occupied structure, or

2) A maximum not-to-exceed sound level of 50 dBC (L_{90C}) from the wind turbines without other ambient sounds for properties located at one mile or more from State Highways or other major roads or 55 dBC (L_{90C}) for properties closer than one mile.

These limits shall be assessed using the same nighttime and wind/weather conditions required in 1.a. Turbine operating sound immissions (L_{eqA} and L_{eqC}) shall represent worst case sound immissions for stable nighttime conditions with low winds at ground level and winds sufficient for full operating capacity at the hub.

3. General Clause

a. Not to exceed 35 dBA within 30 m. (approx. 100 feet) of any occupied structure.

4. Requirements

a. All instruments must meet ANSI or IEC Precision integrating sound level meter performance specifications.

b. Procedures must meet ANSI S12.9 and other applicable ANSI standards.

c. Measurements must be made when ground level winds are 2m/s (4.5 mph) or less. Wind shear in the evening and night often results in low ground level wind speed and nominal operating wind speeds at wind turbine hub heights.

d. IEC 61400-11 procedures are not suitable for enforcement of these requirements except for the presence of tones.

How to Include the Recommended Criteria in Ordinances and/or Community Noise Limits

This next section presents the definitions, technical requirements, and complaint resolution processes that support the recommended criteria. Following the formal elements is a section discussing the measurement procedures and requirements for enforcement of these criteria. For the purpose of this article the government authority will be referred to as the Local Government Authority (LGA) as a place marker for State, County, Township or other authorized authority. The abbreviation 'WES' is used for industrial scale wind energy system.

ELEMENTS OF A WIND ENERGY SYSTEMS LICENSING ORDINANCE FOR SOUND

I. Purpose And Intent.

Based upon the findings stated above, it is the intended purpose of the LGA to regulate Wind Energy Systems to promote the health, safety, and general welfare of the citizens of the Town and to establish reasonable and uniform regulations for the operation thereof so as to control potentially dangerous effects of these Systems on the community.

II. Definitions.

The following terms have the meanings indicated:

"Aerodynamic Sound" means a noise that is caused by the flow of air over and past the blades of a WES.

"Ambient Sound" Ambient noise encompasses all sound present in a given environment, being usually a composite of sounds from many sources near and far. It includes intermittent noise events, such as, from aircraft flying over, dogs barking, wind gusts, mobile farm or construction machinery, and the occasional vehicle traveling along a nearby road. The ambient also includes insect and other nearby sounds from birds and animals or people. The near-by and transient events are all part of the ambient sound environment but are <u>not to be considered part of the background sound.</u> If present, a different time or location should be selected for determining the L_{90} background sound levels.

"Anemometer" means a device for measuring the speed and direction of the wind.

"Applicant" means the individual or business entity that seeks to secure a license under this section of the Town municipal code.

"A-Weighted Sound Level (dBA)" A measure of over-all sound pressure level designed to reflect the response of the human ear, which does not respond equally to all frequencies. It is used to describe sound in a manner representative of the human ear's response. It reduces the effects of the low with respect to the frequencies centered around 1000 Hz. The resultant sound level is said to be "A-weighted" and the units are "dBA." Sound level meters have an A-weighting network for measuring A-weighted sound levels (dBA) meeting the characteristics and weighting specified in ANSI Specifications for Integrating Averaging Sound Level Meters, S1.43-1997 for Type 1 instruments and be capable of accurate readings (corrections for internal noise and microphone response permitted) at 20 dBA or lower.

"**Background Sound (L_{90})** refers to the sounds that would normally be present at least 90% of the time. Background sounds are those heard during lulls in the ambient sound environment. That is, when transient sounds from flora, fauna, and wind are not present. Background sound levels vary during different times of the day and night. Because WES operates 24/7 the background sound levels of interest are those during the quieter periods which are often the evening and night. Sounds from near-by birds and animals or people must be excluded from the background sound test data.

Background sound level (dBA and dBC (as L_{90})) is the sound level present for at least 90% of the time during a period of observation that is representative of the quiet time for the soundscape under evaluation and with duration of ten (10) continuous minutes. Several contiguous ten (10) minute tests may be performed in one hour to determine the statistical stability of the sound environment. Longer term tests, such as 24 hours or multiple days are not appropriate since the purpose is to define the quiet time background sound level. It is defined by the L_{90A} and L_{90C} descriptors. It may be considered to be the quietest one (1) minute during a ten (10) minute test. L_{90A} results are valid only when L_{10A} results are no more than 10 dBA above L_{90A} for the same time period. L_{10C} less L_{90C} should not exceed 15 dBC to be valid.

Measurement periods such as at dusk when bird and insect activity is high or the early morning hours when the 'dawn chorus' is present are not acceptable measurement times. Further, background L_{90} sound levels documenting the pre-construction baseline conditions should be determined when the ten minute average wind speed is 2 m/s (4.5 mph) or less at the ground level/microphone location.

"**Blade Passage Frequency**" (BPF) means the frequency at which the blades of a turbine pass a particular point during each revolution (e.g. lowest point or highest point in rotation) in terms of events per second. A three bladed turbine rotating at 28 rpm would have a BPF of 1.4 Hz. [E.g. ((3 blades times 28rpm)/60 seconds per minute = 1.4 Hz BPF)]

"**C-Weighted Sound Level (dBC)**" Similar in concept to the A-Weighted sound Level (dBA) but C-weighting does not de-emphasize the frequencies below 1k Hz as A-weighting does. It is used for measurements that must include the contribution of low frequencies in a single number representing the entire frequency spectrum. Sound level meters have a C-weighting network for measuring C-weighted sound levels (dBC)meeting the characteristics and weighting specified in ANSI S1.43-1997 Specifications for Integrating Averaging Sound Level Meters for Type 1 instruments.

"**Decibel (dB)**" A dimensionless unit which denotes the ratio between two quantities that are proportional to power, energy or intensity. One of these quantities is a designated reference by which all other quantities of identical units are divided. The sound pressure level (Lp) in decibels is equal to 10 times the logarithm (to the base 10) of the ratio between the pressure squared divided by the reference pressure squared. The reference pressure used in acoustics is 20 MicroPascals.

"**Frequency**" The number of oscillations or cycles per unit of time. Acoustical frequency is usually expressed in units of Hertz (Hz) where one Hz is equal to one cycle per second.

"Height" means the total distance measured from the grade of the property as existed prior to the construction of the wind energy system, facility, tower, turbine, or related facility at the base to its highest point.

"Hertz (Hz)" Frequency of sound expressed by cycles per second.

"Impulsive Sound" refers to short-term acoustical impulses typically lasting less than one second each. It may be the only sound emitted from a noise source or it may be a component of a more complex sound. For evaluation of wind turbines, impulsive sound includes swishing or thumping sounds.

"Infra-Sound" sound with energy in the frequency range of 20 Hz and below is considered to be infrasound is normally considered to not be audible unless in relatively high amplitude. The most significant exterior noise induced dwelling vibration occurs in the frequency range between 5 Hz and 50 Hz. Moreover, even levels below the threshold of audibility can still cause measurable resonances inside dwelling interiors. Conditions that support or magnify resonance may also exist in human body cavities and organs under certain conditions, although no specific test for infrasound is provided in this document, its presence will be accounted for in the comparison of dBA and dBC sound levels for the complaint test provided later in this document. See low-frequency sound (LFN) for more information.

"Low Frequency Sound (LFN)" refers to sounds with energy in the lower frequency range of 20 to 200 Hz. LFN is deemed to be excessive when the difference between a C-weighted sound pressure level and an A-weighted sound pressure level is greater than 20 decibels at any measurement point outside or inside a noise sensitive receptor site, residence, or other occupied structure. E.G. C-A>20 dB.

"Measurement Point (MP)" means location where sound and/or vibration measurements are taken such that no significant obstruction blocks sound and vibration from the site. The Measurement Point should be located so as to not be near large objects such as buildings and in the line-of-sight to the nearest turbines. Proximity to large buildings or other structures should be twice the largest dimension of the structure, if possible.

"Measurement Wind Speed" For measurements conducted to establish the background sound pressure levels (dBA, dBC, $L_{90\,10\,min}$, and etc.) the wind speed at the microphone's Measurement Point shall average 2 m/s (4.5 mph) or less for valid background measurements. For valid measurements conducted to establish the post-construction sound level the wind speed at the microphone's Measurement Point shall not exceed 4m/s (9 mph) average and the wind speed at the WES blade height shall be at or above the nominal rated wind speed. For purposes of enforcement, the wind speed and direction at the WES blade height shall be selected to reproduce the conditions leading to the enforcement action while also restricting wind speeds at the microphone to 4 m/s (9 mph).

For purposes of models used to predict the sound levels and sound pressure levels of the WES to be submitted with the Application, the Wind Speed shall be the speed that will result in the worst-case dBA and dBC sound levels in the community adjacent the nearest WES. For the purpose of constructing the model the wind direction shall consider the dominant wind direction for the seasons from the late Spring to early Fall. If other wind directions may cause levels to exceed those of the predominant wind direction at nearby sensitive receptors, these levels and conditions shall be included in the Application.

"Mechanical Noise" means sound produced as a byproduct of the operation of the mechanical components of a WES(s) such as the gearbox, generator and transformers.

"**Noise**" means any unwanted sound. Not all noise needs to be excessively loud to represent an annoyance or interference.

"**Project Boundary**" means the external property boundaries of parcels owned by or leased by the WES developers.

"**Property Line**" means the recognized and mapped property parcel boundary line.

"**Pure Tone**" A sound for which the sound pressure is a simple sinusoidal function of the time, and characterized by its singleness of pitch. Pure tones can be part of a more complex sound wave that has other characteristics.

"**Qualified Independent Acoustical Consultant**" Qualifications for persons conducting baseline and other measurements and reviews related to the application for a WES or for enforcement actions against an operating WES include, at a minimum, demonstration of competence in the specialty of community noise testing and Full Membership in the Institute of Noise Control Engineers (INCE). Certifications such as Professional Engineer (P.E.) do not test for competence in acoustical principles and measurement and are thus not, without further qualification, appropriate for work under this document. The Independent Qualified Acoustical Consultant can have no financial or other connection to a WES developer or related company.

"**Sensitive Receptor**" means places or structures intended for human habitation, whether inhabited or not, public parks, state and federal wildlife areas, the manicured areas of recreational establishments designed for public use, including but not limited to golf courses, camp grounds and other nonagricultural state or federal licensed businesses. These areas are more likely to be sensitive to the exposure of the noise, vibration, shadow or flicker, etc. generated by a WES or WESF. These areas include, but are not limited to: schools, daycare centers, elder care facilities, hospitals, places of seated assemblage, non-agricultural businesses and residences.

"**Sound**" A fluctuation of air pressure which is propagated as a wave through air

"**Sound Power**" The total sound energy radiated by a source per unit time. The unit of measurement is the watt. Abbreviated as L_w. This information is determined for the WES manufacturer under laboratory conditions specified by IEC 61400-11 and provided to the local developer for use in computer model construction. It cannot be assumed that these values represent the highest sound output for any operating condition. They reflect the operating *conditions required to meet the IEC 61400-11 requirements. The lowest frequency is 50 Hz for* acoustic power (L_w) requirement in IEC 61400-11. This Ordinance requires wind turbine certified acoustic power (L_w) levels at rated load for the total frequency range from 6.3 Hz to 10k Hz in one-third octave frequency bands tabulated to the nearest 0.1 dB. The frequency range of 6.3 Hz to 10k Hz shall be used throughout this Ordinance for all sound level modeling, measuring and reporting.

"**Sound Pressure**" The instantaneous difference between the actual pressure produced by a sound wave and the average or barometric pressure at a given point in space.

"**Sound Pressure Level (SPL)**" 20 times the logarithm, to the base 10, of the ratio of the pressure of the sound measured to the reference pressure, which is 20 micronewtons per square meter. In equation form, sound pressure level in units of decibels is expressed as SPL (dB) = 20 log p/pr.

"**Spectrum**" The description of a sound wave's resolution into its components of frequency and amplitude. The WES manufacturer is required to supply a one-third octave band frequency spectrum of the wind turbine sound emission at 90% of rated power. The published sound spectrum is often presented as A-weighted values. This information is used to project the wind farm sound levels at all locations of interest. Confirmation of the projected sound spectrum can be determined with a small portable one-third octave band frequency (spectrum) analyzer. The frequency range of interest for wind turbine noise is approximately 10 Hz to 10k Hz.

"Statistical Noise Levels" Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, L_{10} is the noise level exceeded for 10% of the time. Of particular relevance, are: L_{A10} and L_{C10} the noise level exceed for 10% of the ten (10) minute interval. This is commonly referred to as the average maximum noise level. L_{A90} and L_{C90} the noise level exceeded for 90% of the ten (10) minute sample period. The L_{90} noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level. Leq is the frequency-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

"Tonal sound (sometimes Pure Tone)" A sound for which the sound pressure is a simple sinusoidal function of the time, and characterized by its singleness of pitch. Tonal sound can be simple or complex.

"Wind Energy Systems (WES)" means equipment that converts and then transfers energy from the wind into usable forms of energy on a large, industrial scale for commercial or utility purposes. Small scale wind systems of less than 170 feet in height with a 60-foot rotor diameter and a nameplate capacity of less than 100 kilowatts or less are exempt from this definition and the provisions of this Ordinance.

"Wind Turbine" or "Turbine" (WTI) means a mechanical device which captures the kinetic energy of the wind and converts it into electricity. The primary components of a wind turbine are the blade assembly, electrical generator and tower.

IV. APPLICATION PROCEDURE FOR WIND ENERGY SYSTEMS

A. Any Person desiring to secure a Wind Energy Systems license shall file an application together with two additional copies of the application with the LGA Clerk.

B. The application shall be on a form provided by the LGA Clerk.

A. Information to be submitted with Application:

1. Information regarding the: make and model of the turbines, Sound Power Levels (L_w) for each one-third octave band from 6.3 Hz up through 10,000 Hz, and a projection showing the expected dBA and dBC sound levels computed using the one-third octave band sound power levels (L_w) with appropriate corrections for modeling and measurement accuracy tolerances and directional patterns of the WTi for all areas within and to one (1) mile from the project boundary for the wind speed, direction and operating mode that would result in the worst case WTi sound emissions.

The prediction model shall assume that the winds at hub height are sufficient for the highest sound emission operating mode even though the enforcement tests will be with ground level winds of 10 mph or less. This is to accommodate enforcement under weather conditions where there is significant difference in the wind speed between ground and hub heights. This condition often occurs during summer evenings when wind shear is affected by the reduction in solar heating of the earth's surface between sunset and sunrise.

The projection may be by means of computer model but shall include a description of all assumptions made in the model's construction and algorithms. If the model does not consider the effects of wind direction, geography of the terrain, and/or the effects of reinforcement from coherent sounds or tones from the turbines these should be identified and other means used to adjust the model's output to account for these factors. These results may be displayed as a contour map of the predicted levels, but should also include a table showing the predicted levels at noise sensitive receptor sites and residences within the model's boundaries. The predicted values must include dBA and dBC values but shall also include un-weighted octave band sound pressure levels from 8 Hz to 10k Hz in data tables.

2. The Town reserves the right to require the preparation of (a) a preconstruction noise survey for each proposed Wind Turbine location conducted per procedures provided here-in and in the Appendix showing background dBA and dBC sound levels ($L_{90\,(10min)}$) over one or more valid ten (10) minute continuous measurement periods prior to approval for the final layout and construction as part of an environmental study evaluating what impact the project may have on sensitive receptors in the vicinity of the proposed WES sites.

a. If any proposed wind farm project locates a WES within one mile of a sensitive receptor these studies are mandatory. The preconstruction baseline studies shall be conducted by an Independent Qualified Acoustical Consultant selected by the LGA.

b. The LGA shall hire an Independent Qualified Acoustical Consultant to conduct the sound study for the LGA as specified in this document. However, the applicant shall be responsible for paying the consultant's fees and costs associated with conducting the study. These fees and cost shall be negotiated with the consultant and determined prior to any work being done on the study. The applicant shall be required to set aside 100% of these fees in an escrow account managed by the LGA, before the study is commenced by the consultant. Payment for this study does not require the WES developer's acceptance of the study's results.

c. If the review shows that the predicted dBA or dBC sound levels exceed the criteria specified in this document then the application cannot be approved.

3. The LGA will refer the application to the LGA engineer (if qualified in acoustics) or an independent qualified acoustical consultant for further review and comparison against the predicted dBA and dBC sound levels supplied with the application. The reasonably necessary costs associated with the review of the sound study shall be the responsibility of the applicant, in accord with the terms of this ordinance.

V. TECHNICAL REQUIREMENTS FOR LICENSING

This ordinance is intended to promote the safety and health of the community through criteria limiting sound emissions during operation of Wind Energy Systems. It is recognized that the requirements herein are neither exclusive, nor exhaustive. In instances where a health or safety concern is known to the wind project developer or identified by other means with regard to any application for a Wind Energy System, additional and/or more restrictive conditions may be included in the license to address such concerns. All rights are reserved to impose additional restrictions as circumstances warrant. Such additional or more restrictive conditions may include, without limitation (a) greater setbacks, (b) more restrictive noise limitations, or (c) limits restricting operation during night time periods or for any other conditions deemed reasonable to protect the community.

A. Sound.

1. Sound Regulations Compliance: A WES shall be considered in violation of the conditional use permit unless the applicant demonstrates that the project complies with all sound level limits. Sound levels in excess of the limits established in this ordinance shall be grounds for the LGA to order immediate shut down of all non-compliant WTi.

2. **Post-Construction Sound Measurements**: Within twelve months of the date when the project is fully operational, and within four weeks of the anniversary date of the pre-construction background noise measurements, repeat the existing sound environment measurements taken before the project approval. Post-construction sound level measurements shall be taken both with all WES's running and with all WES's off. At the discretion of the Town, the Pre-construction background sound levels (L_{90A}) can be substituted for the "all WES off" tests if a random sampling of 10% of the pre-construction study sites shows that background $L_{90A \text{ and } C}$ conditions have not changed more than +/- 5 dB (dBA and dBC) measured under the pre-construction nighttime meteorological conditions. The post-construction measurements will be reported to the LGA (available for public review) using the same format as used for the preconstruction sound studies. Post-construction noise studies shall be conducted by a firm chosen by the LGA. Costs of these studies are to be reimbursed by the Licensee in a similar manner to that described above. The wind farm developer's own consultant is free to observe the publicly retained consultant at the convenience of the latter. The WES developer/applicant shall provide all technical information and wind farm data required by the independent qualified acoustical consultant before, during, and/or after any acoustical studies required by this document and for local area acoustical measurements.

3. Sound Limits

1. Audible Sound Limit

a. No WTi or WES shall be located so as to cause an exceedance of the pre-construction/operation background sound levels by more than 5 dBA. The background sound levels shall be the L_{90A} sound descriptor measured during a pre-construction noise study during the quietest time of night (10pm until 4am). All data sampling shall be one or more contiguous ten (10) minute measurements. L_{90A} results are valid when L_{10A} results are no more than 10 dBA above L_{90A} for the same time period and L_{10C} less L_{90C} is no more than 15 dBC. Noise sensitive sites are to be selected based on wind development's predicted worst-case sound emissions (in L_{eqA} and L_{eqC}) which are to be provided by developer.
b. Test sites are to be located along the property line(s) of the receiving non-participating property(s).
c. A 5 dB penalty is applied for tones as defined in IEC 61400-11.

2. Low Frequency Sound Limit

a. The L_{eqC} and L_{90C} sound levels from the wind turbine at the receiving property shall not exceed either:
   1) L_{eqC}-L_{90A} greater than 20 dB outside any occupied structure, or
   2) A maximum not-to-exceed sound level of 50 dBC (L_{90C}) from the wind turbines without contribution from other ambient sounds for properties

located one mile or more away from state highways or other major roads or 55 dBC (L_{90C}) for properties closer than one mile.

These limits shall be assessed using the same nighttime and wind/weather conditions required in 1.a. Turbine operating sound immissions shall represent worst case sound immissions for stable nighttime conditions with low winds at ground level and winds sufficient for full operating capacity at the hub.

3. General Clause

a. Not to exceed 35 $dBA_{Leq\ 10\ min.}$ within 30 m. (approx. 100 feet) of any occupied structure.

4. Operations Exceeding any of the limits in this section will be considered as proof that the WES/WTi is non-compliant and must be shut down immediately.

5. Requirements

a. All instruments must meet ANSI or IEC Type 1 Precision integrating sound level meter performance specifications.

b. Procedures must meet ANSI S12.9 Part 3 including the addendum in the Appendix to this document. Where there are differences between the procedures and definitions of this document and ANSI standards the procedures and definitions of this document will be applied. Where a standard's requirements may conflict with other standards the most stringent requirement shall be followed.

c. Measurements for background sound levels must be made when ground level winds are 2m/s (4.5 mph) or less with wind speeds at the hub at or above nominal operating requirements and for other tests when ground level winds are 4m/s (9 mph). Weather in the night often results in low ground level wind speed and nominal operating wind speeds at wind turbine hub heights.

d. IEC 61400-11 procedures are not suitable for enforcement of these requirements except for the presence of tones.

4. Complaint Resolution

1. The owner/operator of the WES shall respond within five (5) business days after notified of a noise complaint by any property owner within the project boundary and a one-mile radius beyond the project boundary.

2. The tests shall be performed by a qualified acoustical consultant acceptable to the complainant and the local agency charged with enforcement of this ordinance.

3. Testing shall commence within ten (10) working days of the request. If testing cannot be initiated within ten (10) days, the WES(s) in question shall be shut down until the testing can be started.

4. A copy of the test results shall be sent to the property owner, and the LGA's Planning or Zoning department within thirty (30) days of test completion.

5. If a Complaint is made, the presumption shall be that it is reasonable. The LGA shall undertake an investigation of the alleged operational violation by a qualified individual mutually acceptable to the LGA.

   a) The reasonable cost and fees incurred by the LGA in retaining said qualified individual shall be reimbursed by the owner of the WESF.

b) Funds for this assessment shall be paid or put into an escrow account prior to the study and payment shall be independent of the study findings.

5. After the investigation, if the LGA reasonably concludes that operational violations are shown to be caused by the WESF, the licensee/operator/owner shall use reasonable efforts to mitigate such problems on a case-by-case basis including such measures as not operating during the night time or other noise sensitive period if such operation was the cause of the complaints.

5. Reimbursement of Fees and Costs.

Licensee/operator/owner agrees to reimburse the LGA 's actual reasonable fees and costs incurred in the preparation, negotiation, administration and enforcement of this Ordinance, including, without limitation, the LGA 's attorneys' fees, engineering and/or consultant fees, LGA meeting and hearing fees and the costs of public notices. If requested by the LGA the funds shall be placed in an escrow account under the management of the LGA. The preceding fees are payable within thirty (30) days of invoice. Unpaid invoices shall bear interest at the rate of 1% per month until paid. The LGA may recover all reasonable costs of collection, including attorneys' fees.

MEASUREMENT PROCEDURES

APPENDIX TO WIND ENERGY SYSTEMS LICENSING ORDINANCE FOR SOUND

I. Introduction

The potential impact of sound and sound induced building vibration associated with the operation of wind powered electric generators is often a primary concern for citizens living near proposed wind energy systems (WES(s)). This is especially true of projects located near homes, residential neighborhoods, businesses, schools, and hospitals in quiet residential and rural communities. Determining the likely sound and vibration impacts is a highly technical undertaking and requires a serious effort in order to collect reliable and meaningful data for both the public and decision makers.

This protocol is based in part on criteria published in American National Standards S12.9 - Quantities and Procedures for Description and Measurement of Environmental Sound, and S12.18 and for the measurement of sound pressure level outdoors.

The purpose is to first, establish a consistent and scientifically sound procedure for evaluating existing background levels of audible and low frequency sound in a WES project area, and second to use the information provided by the Applicant in its Application showing the predicted over-all sound levels in terms of dBA and dBC[16] as part of the required information submitted with the application.

These values shall be presented as overlays to the applicant's iso-level plot plan graphics (dBA and dBC) and in tabular form with location information sufficient to permit comparison of the baseline results to the predicted levels. This comparison will use the level limits of the ordinance to determine the likely impact operation of a new wind energy system project will have on the

[16] Calculated from one-third octave band sound power levels (L_W per IEC 61400-11) provided by the wind turbine manufacturer covering the frequency range from 6.3 Hz to 10,000 HZ or higher.

existing community soundscape. If the comparison demonstrates that the WES project will not exceed any of the level limits the project will be considered to be within allowable limits for safety and health. If the Applicant submits only partial information required for this comparison the application cannot be approved. In all cases the burden to establish the operation as meeting safety and health limits will be on the Applicant.

Next it addresses requirements for the sound propagation model to be supplied with the application.

Finally, if the project is approved, this Appendix covers the study needed to compare the post-build sound levels to the predictions and the baseline study. The level limits in the ordinance apply to the post-build study. In addition, if there have been any complaints about WES sound or low frequency noise emissions by any resident of an occupied dwelling that property will be included in the post-build study for evaluation against the rules for sound level limits and compliance.

The characteristics of the proposed WES project and the features of the surrounding environment will influence the design of the sound and vibration study. Site layout, types of WES(s) selected and the existence of other significant local audible and low frequency sound sources and sensitive receptors should be taken into consideration when designing a sound and vibration study. The work will be performed by an independent qualified acoustical consultant for both the pre-construction background and post-construction sound studies as described in the body of the ordinance.

II. Instrumentation

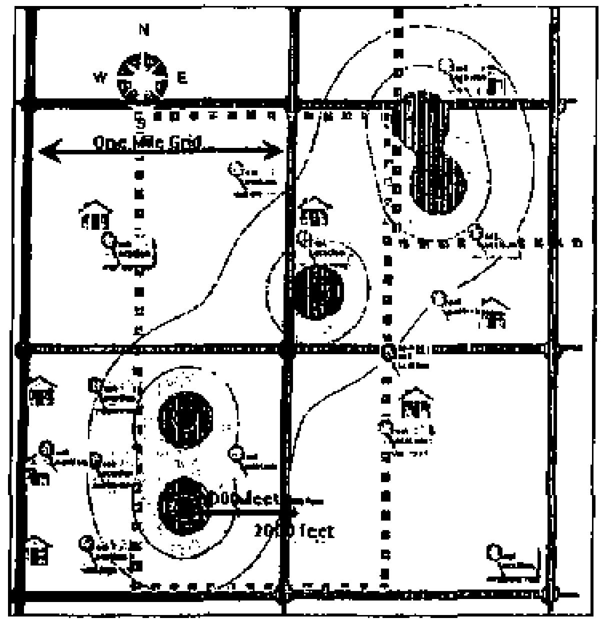
All instruments and other tools used to measure audible, inaudible and low frequency sound shall meet the requirements for ANSI or IEC Type 1 Integrating Averaging Sound Level Meter with one-third octave band analyzer with frequency range from 6.3 Hz to 20k Hz and capability to simultaneously measure dBA L_N and dBC L_N. The instrument must also be capable of measuring low level background sounds down to 20 dBA. Measurements shall only be made with the instrument manufacturer's approved wind screen. A compatible acoustic field calibrator is required with certified ± 0.2 dB accuracy. Portable meteorological measurement requirements are outlined in ANSI S12.9 Part 3 and are required to be located within 5m of the sound measuring microphone. The microphone shall be located at a height of 1.2 to 1.5 meters for all tests unless circumstances require a different measurement position. In that case, the reasons shall be documented and include any adjustments needed to make the results correspond to the preferred measurement location.

III. Measurement of Pre-Construction Sound Environment (Base-lines)

An assessment of the proposed WES project areas existing sound environment is necessary in order to predict the likely impact resulting from a proposed project. The following guidelines must be used in developing a reasonable estimate of an area's existing background sound environment. All testing is to be performed by an independent qualified acoustical consultant approved by the LGA as provided in the body of the ordinance. The WES applicant may file objections detailing any concerns it may have with the LGA's selection. These concerns will be addressed in the study. Objections must be filed prior to the start of the noise study. All measurements are to be conducted with ANSI or IEC Type 1 certified and calibrated test equipment per reference specification at the end of this Appendix. Test results will be reported to the LGA or its appointed representative.

Sites with No Existing Wind Energy Systems (Base-line Sound Study)

Sound level measurements shall be taken as follows:



The results of the model showing the predicted worst case dBA and dBC sound emissions of the proposed WES project will be overlaid on a map (or separate dBA and dBC maps) of the project area. An example (right) shows an approximately two (2) mile square section with iso-level contour lines prepared by the applicant, sensitive receptors (homes) and locations selected for the baseline dBA and dBC sound tests whichever are the controlling metric. The test points shall be located at the property line bounding the property of the turbine's host closest to the wind turbine. Additional sites may be added if appropriate. A grid comprised of one (1) mile boundaries (each grid cell is one (1) square mile) should be used to assist in identifying between two (2) to ten (10) measurement points per cell. The grid shall extend to a minimum of one (1) mile beyond the perimeter of the project boundary. This may be extended to more than one mile at the discretion of the LGA. The measurement points shall be selected to represent the noise sensitive receptor sites based on the anticipated sound propagation from the combined WTi in the project. Usually, this will be the closest WTi. If there is more than one WTi near-by then more than one test site may be required.

The intent is to anticipate the locations along the bounding property line that will receive the highest sound immissions. The site that will be most likely negatively affected by the WES project's sound emissions should be given first priority in testing. These sites may include sites adjacent to occupied dwellings or other noise sensitive receptor sites. Sites shall be selected to represent the locations where the background soundscapes reflect the quietest locations of the sensitive receptor sites. Background sound levels (and one-third octave band sound pressure levels for the sound measuring consultants file) shall be obtained according to the definitions and procedures provided in the ordinance and recognized acoustical testing practice and standards.

All properties within the proposed WES project boundaries will be considered for this study.

One test shall be conducted during the period defined by the months of April through November with the preferred time being the months of June through August. These months are normally associated with more contact with the outdoors and when homes may have open windows during the evening and night. Unless directed otherwise by the LGA the season chosen for testing will represent the background soundscape for other seasons. At the discretion of the LGA, tests may be scheduled for other seasons.

All measurement points (MPs) shall be located with assistance from with the LGA staff and property owner(s) and positioned such that no significant obstruction (building, trees, etc.) blocks sound and vibration from the nearest proposed WES site.

Duration of measurements shall be a minimum of ten continuous minutes for each criterion at each location. The duration must include at least 6 minutes that are not affected by transient sounds from near-by and non-nature sources. Multiple 10 minute samples over longer periods such as 30 minutes or one (1) hour may be used to improve the reliability of the L_{90} values. The ten minute sample with the lowest valid L_{90} values will be used to define the background sound.

The tests at each site selected for this study shall be taken during the expected 'quietest period of the day or night' as appropriate for the site. For the purpose of determining background sound characteristics the preferred testing time is from 10pm until 4 am. If circumstances indicated that a different time of the day should be sampled the test may be conducted at the alternate time if approved by the Town.

Sound level measurements must be made on a weekday of a non-holiday week. Weekend measurements may be taken at selected sites where there are weekend activities that may be affected by WTi sound.

Measurements must be taken at 1.2 to 1.5 meters above the ground and at least 15 feet from any reflective surface following ANSI 12.9 Part 3 protocol including selected options and other requirements outlined later in this Section.

Reporting

1. For each Measurement Point and for each measurement period, provide each of the following measurements:

   a. L_{Aeq}, L_{10}, and L_{90}, in dBA

   b. L_{Ceq}, L_{10}, and L_{90}, in dBC

2. A narrative description of any intermittent sounds registered during each measurement. This may be augmented with video and audio recordings.

3. A narrative description of the steady sounds that form the background soundscape. This may be augmented with video and audio recordings.

4. Wind speed and direction at the Measurement Point, humidity and temperature at time of measurement will be included in the documentation. Corresponding information from the nearest 10 meter weather reporting station shall also be obtained.

Measurements taken when wind speeds exceed 2m/s (4.5 mph) at the microphone location will not be considered valid for this study. A windscreen of the type recommended by the monitoring instrument's manufacturer must be used for all data collection.

5. Provide a map and/or diagram clearly showing (Using plot plan provided by LGA or Applicant):

- The layout of the project area, including topography, the project boundary lines, and property lines.
- The locations of the Measurement Points.
- The minimum and maximum distance between any Measurement Points.
- The location of significant local non-WES sound and vibration sources.
- The distance between all MPs and significant local sound sources. And,
- The location of all sensitive receptors including but not limited to: schools, day-care centers, hospitals, residences, residential neighborhoods, places of worship, and elderly care facilities.

Sites with Existing Wind Energy Systems

Two complete sets of sound level measurements must be taken as defined below:

1. One set of measurements with the wind generator(s) off unless the LGA elects to substitute the sound data collected for the background sound study collected as part of an earlier baseline study. Wind speeds must be suitable for background testing.

2. One set of measurements with the wind generator(s) running with wind speed at hub height sufficient to meet nominal power output or higher and at 2 m/s or below at the microphone location. Conditions should reflect the worst case sound emissions from the WES project. This will normally involve tests taken during the evening or night when winds are calm (2m/sec or less) at the ground surface yet, at hub height, sufficient to operate the turbines.

Sound level measurements and meteorological conditions at the microphone shall be taken and documented as discussed above.

Sound level Estimate for Proposed Wind Energy Systems (when adding more WTI to existing project)

In order to estimate the sound impact of the proposed WES project on the existing environment an estimate of the sound produced by the proposed WES(s) under worst-case conditions for producing sound emissions must be provided. This study may be conducted by a firm chosen by the WES operator with oversight provided by the LGA.

The qualifications of the firm should be presented along with details of the procedure that will be used, software applications, and any limitations to the software or prediction methods.

Provide the manufacturer's sound power level (Lw) characteristics for the proposed WES(s) operating at full load utilizing the methodology in IEC 61400-11 Wind Turbine Noise Standard. Provide one-third octave band L_w sound power level information from 6.3 Hz to 10k Hz. Furnish the data with and without A-weighting. Provide sound pressure levels predicted for the WES(s) in combination and at full operation and at maximum sound power output for all areas where the predictions indicate dBA levels of 30 dBA and above. The same area shall be used for reporting the predicted dBC levels. Contour lines shall be in increments of 5 dB.

Present tables with the predicted sound levels for the proposed WES(s) in dBA, dBC and at all octave band centers (8 Hz to 10k Hz) for distances of 500, 1000, 1500, 2000, 2500 and 5000 feet from the center of the area with the highest density of WES(s). For projects with multiple WES(s), the combined sound level impact for all WES(s) operating at full load must be estimated.

The above tables must include the impact (increased dBA and dBC above baseline L_{90} Background sound levels) of the WES operations on all residential and other noise sensitive receiving locations within the project boundary. To the extent possible, the tables should include the sites tested in the background study.

Provide a contour map of the expected sound level from the new WES(s), using 5 dBA and 5 dBC increments created by the proposed WES(s) extending out to a distance of at least 2500 feet from the project boundary or the 35 dBA or 50 dBC boundary whichever is greater.

Provide a description of the impact of the proposed sound from the WES project on the existing environment. The results should anticipate the receptor sites that will be most negatively impacted by the WES project and to the extent possible provide data for each MP that are likely to be selected in the background sound study (note the sensitive receptor MPs):

1. Report expected changes to existing sound levels for L_{Aeq}, L_{10} and L_{90}, in dBA
2. Report expected changes to existing sound levels for L_{Ceq}, L_{10} and L_{90}, in dBC
3. Report the predicted sound pressure levels for each of the 1/1 octave bands as un-weighted dB in tabular form from 8 Hz to 10k Hz.
4. Report all assumptions made in arriving at the estimate of impact, any limitations that might cause the sound levels to exceed the values of the estimate, and any conclusions reached regarding the potential effects on people living near the project area. If the effects of coherence, worst case weather, or operating conditions are not reflected in the model a discussion of how these factors could increase the predicted values is required.
5. Include an estimate of the number of hours of operation expected from the proposed WES(s) and under what conditions the WES(s) would be expected to run. Any differences from the information filed with the Application should be addressed.

IV. Post-Construction Measurements

Post Construction Measurements should be conducted by a qualified noise consultant selected by and under the direction of the LGA. The requirements of this Appendix for Sites with Existing Wind Energy Systems shall apply

1. Within twelve months of the date when the project is fully operational, and within two weeks of the anniversary date of the Pre-construction ambient noise measurements, repeat the existing sound environment measurements taken before the project approval. Post-construction sound level measurements shall be taken both with all WES(s) running and with all WES(s) off except as provided the ordinance.

2. Report post-construction measurements to the LGA using the same format as used for the background sound study.

3 Project Boundary: A continuous line encompassing all WES(s) and related equipment associated with the WES project.

V. REFERENCES

ANSI/ASA S12.9-1993/Part 3 (R2008) - American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 3: Short-Term Measurements with an Observer Present.

This standard is the second in a series of parts concerning description and measurement of outdoor environmental sound. The standard describes recommended procedures for measurement of short-term, time-average environmental sound outdoors at one or more locations in a community for environmental assessment or planning for compatible land uses and for other purposes such as demonstrating compliance with a regulation. These measurements are distinguished by the requirement to have an observer present. Sound may be produced by one or more separate, distributed sources of sound such as a highway, factory, or airport. Methods are given to correct the measured levels for the influence of background sound.

For the purposes of this ordinance the options that are provided in ANSI S12.9-Part 3 (2008) shall be applied with the additional following requirements:

Wind Turbine Siting Acoustical Measurements
ANSI S12.9 Part 3 Selection of options and other requirements

5.2 background sound: Use definition (1) 'long-term'
5.3 long-term background sound: The L_{90} excludes short term background sounds
5.4 basic measurement period: Ten (10) minutes $L_{90(10\,min)}$
5.6 Sound Measuring Instrument: Type 1 integrating meeting ANSI S1.43
6.5 Windscreen: Required
7.1 Long-term background sound
7.2 Data collection Methods: Second method Observed samples to avoid contamination by short term sounds (purpose: to avoid loss of statistical data)
8 Source(s) Data Collection: All requirements in ANSI S12.18 Method #2 precision to the extent possible while still permitting testing of the conditions that lead to complaints.
8.3(a) All meteorological observations required at both (not either) microphone and nearest 10m weather reporting station.
8.3(b) For a 10 minute sound measurement to be valid the wind velocity shall not exceed 2m/s (4.5 mph) measured less than 5m from the microphone. Compliance sound measurements shall not be taken when winds exceed 4m/s.
8.3(c) In addition to the required acoustic calibration checks the sound measuring instrument internal noise floor must also be checked at the end of each series of ten minute measurements and no less frequently than once per day. Insert the microphone into the acoustic calibrator with the calibrator signal off. Record the observed dBA and dBC reading from the sound level meter or other recording instrument to determine an approximation of the instrument self noise. This calibrator covered microphone must demonstrate that the results of this test are at least 5 dB below the immediately previous ten minute acoustic test results for the acoustic data to be valid. This test is necessary to detect undesired increase in the microphone and sound level meter internal self noise. As a precaution sound measuring instrumentation should be removed from any air conditioned space at least an hour before use. Nighttime measurements are often performed very near the dew point. Minor moisture condensation inside a microphone or sound level meter can increase the instrument self noise and void the data.
8.4 to the end: The remaining sections of ANSI S12.9 Part 3 Standard do not apply.

ANSI S12.18-1994 (R2004) American National Standard Procedures for Outdoor Measurement of Sound Pressure Level

This American National Standard describes procedures for the measurement of sound pressure levels in the outdoor environment, considering the effects of the ground, the effects of refraction due to wind and temperature gradients, and the effects due to turbulence. This standard is focused on measurement of sound pressure levels produced by specific sources outdoors. The measured sound pressure levels can be used to calculate sound pressure levels at other distances from the source or to extrapolate to other environmental conditions or to assess compliance with regulation. This standard describes two methods to measure sound pressure levels outdoors. METHOD No. 1: general method; outlines conditions for routine measurements. METHOD No. 2: precision method; describes strict conditions for more accurate measurements. This standard assumes the measurement of A-weighted sound pressure level or time-averaged sound pressure level or octave, 1/3-octave or narrow-band sound pressure level, but does not preclude determination of other sound descriptors.

ANSI S1.43-1997(R2007) American National Standard Specifications for Integrating Averaging Sound Level Meters

This Standard describes instruments for the measurement of frequency-weighted and time-average sound pressure levels. Optionally, sound exposure levels may be measured. This standard is consistent with the relevant requirements of ANSI S1.4-1983(R 1997) American National Standard Specification for Sound Level Meters, but specifies additional characteristics that are necessary to measure the time-average sound pressure level of steady, intermittent, fluctuating, and impulsive sounds.

ANSI S1.11-2004 American National Standard 'Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters'

This standard provides performance requirements for analog, sampled-data, and digital implementations of bandpass filters that comprise a filter set or spectrum analyzer for acoustical measurements. It super-sedes ANSI S1.11-1986 (R1998) American National Standard Specification for Octave-Band and Frac-tional-Octave-Band Analog and Digital Filters, and is a counterpart to International Standard IEC 61260:1995 Electroacoustics - Octave-Band and Fractional-Octave-Band Filters. Significant changes from ANSI S1.11-1986 have been adopted in order to conform to most of the specifications of IEC 61260:1995. This standard differs from IEC 61260:1995 in three ways: (1) the test methods of IEC 61260 clauses 5 is moved to an informative annex, (2) the term 'band number,' not present in IEC 61260, is used as in ANSI S1.11-1986, (3) references to American National Standards are incorporated, and (4) minor editorial and style differences are incorporated.

ANSI S1.40-2006 American National Standard Specifications and Verification Procedures for Sound Calibrators

IEC 61400-11

Second edition 2002-12, Amendment 1 2006-05

IEC 61400-11

Second edition 2002-12, Amendment 1 2006-0

Wind turbine generator systems –Part 11: Acoustic noise measurement techniques

The purpose of this part of IEC 61400 is to provide a uniform methodology that will ensure consistency and accuracy in the measurement and analysis of acoustical emissions by wind turbine generator systems. The standard has been prepared with the anticipation that it would be applied by:

- the wind turbine manufacturer striving to meet well defined acoustic emission performance requirements and/or a possible declaration system;
- the wind turbine purchaser in specifying such performance requirements;
- the wind turbine operator who may be required to verify that stated, or required, acoustic performance specifications are met for new or refurbished units;
- the wind turbine planner or regulator who must be able to accurately and fairly define acoustical emission characteristics of a wind turbine in response to environmental regulations or permit requirements for new or modified installations.

This standard provides guidance in the measurement, analysis and reporting of complex acoustic emissions from wind turbine generator systems. The standard will benefit those parties involved in the manufacture, installation, planning and permitting, operation, utilization, and regulation of wind turbines. The measurement and analysis techniques recommended in this document should be applied by all parties to insure that continuing development and operation of wind turbines is carried out in an atmosphere of consistent and accurate communication relative to environmental concerns. This standard presents measurement and reporting procedures expected to provide accurate results that can be replicated by others.

END OF PROCEDURE

Why ObC must be used. Submitted 2/11/09.
Latest research — The WTS is verified.

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Tuning and sensitivity of the human vestibular system to low-frequency vibration

Neil P. McAngus Todd[a,*], Sally M. Rosengren[b], James G. Colebatch[b]

[a] Faculty of Life Science, Jacksons Mill, University of Manchester, Manchester M60 1QD, UK
[b] Prince of Wales Clinical School and Medical Research Institute, University of New South Wales, Randwick, Sydney, NSW 2031, Australia

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ABSTRACT

Mechanoreceptive hair-cells of the vertebrate inner ear have a remarkable sensitivity to displacement, whether excited by sound, whole-body acceleration or substrate-borne vibration. In response to seismic or substrate-borne vibration, thresholds for vestibular afferent fibre activation have been reported in anamniotes (fish and frogs) in the range −120 to −90 dB re 1 g. In this article, we demonstrate for the first time that the human vestibular system is also extremely sensitive to low-frequency and infrasound vibrations by making use of a new technique for measuring vestibular activation, via the vestibulo-ocular reflex (VOR). We found a highly tuned response to whole-head vibration in the transmastoid plane with a best frequency of about 100 Hz. At the best frequency we obtained VOR responses at intensities of less than −70 dB re 1 g, which was 15 dB lower than the threshold of hearing for bone-conducted sound in humans at this frequency. Given the likely synaptic attenuation of the VOR pathway, human receptor sensitivity is probably an order of magnitude lower, thus approaching the seismic sensitivity of the frog ear. These results extend our knowledge of vibration-sensitivity of vestibular afferents but also are remarkable as they indicate that the seismic sensitivity of the human vestibular system exceeds that of the cochlea for low-frequencies.

The otolith organs, the sacculus, utriculus and lagena, primarily respond to whole-body acceleration or tilt in gravity [9]. In fish these also are important auditory structures for acoustic near-field (particle motion) sensing [13,17]. Several studies have determined behavioral particle motion audiograms for non-specialist species of fish, e.g. the cod, plaice and dab [4]. These have indicated that the region of best sensitivity lies between 40 and 120 Hz, with threshold acceleration values of about −120 dB re 1 g at 80 Hz. During the course of evolution the amniote ear developed new structures for far-field (sound pressure) hearing in air, including the basilar papilla and the mammalian cochlea [6].

It has been established, however, that the otolith organs in terrestrial vertebrates have conserved a particular sensitivity to substrate- or bone-conducted sound [2,15,16,22] consistent with their function as near-field sound sensors in fish [4]. In some species of frog the saccule shows a fish-like band-pass response to acceleration with best frequencies between 20 and 160 Hz and thresholds between −90 and −120 dB re 1 g, while others show a low-pass response with best frequencies at 10–20 Hz [14]. Sensitivity to audio-frequency vibration has also been demonstrated in mammalian vestibular organs. In the monkey [27] best frequencies were between 125 and 177 Hz, with phase-locking threshold as low as −80 dB re 1 g, and in the guinea-pig at 500 Hz thresholds were 10 dB above the ABR threshold [3]. At present, however, no such threshold measurements have been obtained for the human vestibular system and this was the aim of our study.

Non-invasive assessment of human vestibular sensitivity can be accomplished by measurement of the powerful vestibulo-ocular reflexes (VOR) to head acceleration. The VOR normally serves to maintain eye gaze with head tilt or rotation and its main effects are mediated by a simple three-neuron arc connecting the vestibular portion of the 8th nerve to the motor neurones of the extraocular muscles [1]. In response to stimuli such as head movements, reflex activity occurs in the extraocular muscles, producing a compensatory eye movement. By placing surface electrodes around the eyes, synchronous muscle activity can be recorded in the form of ocular vestibular evoked myogenic potentials (OVEMPs) [23,25]. These responses are vestibular, rather than cochlear, in origin as they are present in deaf patients but are absent in patients with loss of vestibular function [18,24]. We aimed to measure the tuning and sensitivity of OVEMPs to whole head vibration in the transmastoid plane.

Four volunteers (2 females and 2 males between 31 and 52 years of age) with no auditory or vestibular deficits were stimulated using sinusoidal accelerations between 12.5 and 800 Hz (12.5, 25, 50, 100, 200, 400 and 800 Hz). The subjects were seated

* Corresponding author. Tel.: +44 161 306 5770; fax: +44 161 306 3887.
E-mail address: neil.todd@manchester.ac.uk (N.P.M. Todd).

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Vestibulo ocular Reflex Very sensitive in humans — why Turbines cause damage

E-COUSTICA Replies:
Submitted by [signature] 2/11/09

I will add that your pre-turbine background sound levels (L_{A90}) were probably even lower than 25 dB if measured carefully. I routinely find background sound levels in the range of 18-25 dBA in rural settings not located near highways that are busy at night.

On the topic of Hearing loss, the most sensitive people start to show hearing loss when the average sound level over a typical day is consistently over 70 dBA for years at a time. The 90 dBA limit for an eight (8) hour work-shift was set back in the 1960's under the assumption that the work hours would have 16 hours of "quiet-time" between each work day for the ears to recover before being assaulted by noise again. If they were to be revised today they would be considerable lower than 90 dBA. Probably 80-85 dBA. Further, the mechanism of harm from wind turbine sounds (see Pierpont for details www.windturbinesyndrome.com) is different than the mechanism that causes normal noise-induced hearing loss.

The first form of harm from wind turbine noise is economic and asthetic. The outdoors near homes within about a mile of a wind turbine has sound levels of 45-55 dBA. This is no longer the natural sound of the outdoors in a rural setting. That is, the wind turbine noise masks the normal soundscape and so the sounds of nature which were present 24/7/365 are now covered by the noise of the whooshing wind turbine blades. This has an annoyance effect and thus limits the use of outdoor properties since the soundscape that made the rural home's outdoors "special" has been destroyed. With wind turbines in place an outdoor walk or party is not much different than if one lived near a busy highway in an urban area. It is not a stroll through nature anymore. Sitting around at an outdoor party is not the same either. Instead of listening to the sounds of nature that make the outdoors so refreshing and enjoyable like the birds, tree frogs and other sources of natural ambient sound; one hears wind turbines. Thus, whatever economic and psychological assets one has in a 'country home' are lost. This is reflected in lower property values and loss of use of one's property for the purposes it was originally purchased. Thus, the outdoor noise from wind turbines does harm a local property owner both economically and psychologically primarily due to annoyance at the loss of the pre-turbine conditions and being forced to 'live' with the same negatives as suburbanites without any of the benefits of suburban living (if there are any).

The second form of harm is that the sound of the wind turbines can easily penetrate modern wood frame homes with little or no loss in intensity. Inside one's home, especially with windows closed, the wind turbine sounds are predominantly the lower frequency sounds. Most homes, especially at night when appliances and entertainment equipment are off, are much quieter than the outside. I have measured bedrooms in homes near highways where the nighttime sound levels are less than 20 dBA. I have measured sound levels of less than 30 dBA inside bedrooms during the daytime, with windows open, a TV on in a room down the hall, and with the refrigerator running in the kitchen. This quiet interior condition can lead to the wind turbines seeming to be as noisy or even noisier inside a home than outside. The wind industry likes to say that a turbine is no louder than a conversation or a refrigerator. While they may be able to point to data to support that statement (carefully cherry-picked data) they do not continue their 'example' by asking how many people would like to have a refrigerator in their bedroom or a conversation being held right outside their bedroom window every night. This is explained in more detail in the "The 'How to'... Guide" by Mr. Kamperman and James available on Dr. Pierpont's web site, but to sum it up, the wind turbine sound inside a home leads to sleep disturbance. People who are subjected to repeated sleep disturbance find that it leads to physical and mental health risks that are not trivial and if not address can lead to permanent pathologies that affect one's quality of life and other aspects of overall health. The group most at risk includes children, especially those six and under; people with pre-existing health issues, especially if that includes sleep disorders; and seniors who are healthy but susceptible to sleep disturbance. One only needs to look at how many commercials are for products to help get a good night's sleep to understand that this 'sensitive' group is not small, it may even be a majority of those who are young or old.

The third form of harm is from the very low frequency sounds that are generally in-audible, even inside a home, but may be perceived as a vibration or physical movement of a body organ, like the chest cavity, heart or eyes. The very lowest frequency sound emissions from wind turbines (0 Hz to about 50 Hz) penetrate all home walls and roofs without any attenuation. This frequency range is also where the majority of the acoustic energy is located in the wind turbine sound. Compared to other health issues, very little research has been done on how low frequency sound, at the levels found in homes near wind projects, affects health over long periods of time. Most other sources of similar low frequency sound are not part of the normal soundscape in residential areas on a 24/7/365 basis. Further, these low frequency sounds can interact with the shape and size of interior rooms resulting in a resonant condition where the sound energy from the wind turbines builds up to levels that can be significantly higher that what would be measured if the room did not resonate. Thus, each home has its own impact on how intense the low frequency energy may be inside and it can vary from room to room in the same home.

What research has been done has been primarily for the military such as the Air Force and Navy where the large airplanes and ships may subject some or all of the occupants to sustained exposure to very low frequency sound. The research that has been done on homes affected by wind turbine's has been primarily by

Mariana Alves-Pereira and the VAD Team (Portugal, see attached document for current status of studies) and Dr. Nina Pierpont (web version of study available at www.windturbinesyndrome.com). There are several other studies that are less rigorous, but all of them are indicating that there is a relationship between long term exposure to wind turbine sounds and the health of the people who are living closer than 1 mile from the wind projects. At this time, the suspected cause is the low frequency energy (0-50 Hz, maybe up to 100 Hz) which carries both the bulk of the acoustic energy from wind turbines and also is not reduced, and may be amplified, by modern home construction.

Please read the web version of Dr. Pierpont's work for the details. It should be noted that Dr. Pierpont's prior work was discounted by the wind industry (not the medical community, just the pro-wind non-medical promoters) on the basis that it was not 'peer' reviewed. This new study has been thoroughly peer reviewed and the comments of the peer reviewers are both favorable and available as part of the published study. At this time, it is no longer true to say there is no evidence that wind turbines cause health risks. That position, often stated by the wind industry, is not longer supportable given the work of Dr. Pierpont, the VAD team, and others. This means that wind turbine siting should include oversight from the State's Public Health agency. The risks to public health from wind turbines are well enough established that your local public health agency and your local doctors should be involved in developing any siting standards. It also means that attempts by the wind industry to get setbacks of anything less than one mile are ignoring current medical research.

Rick

Submitted by

E-Coustic Solutions

Okemos, MI 48805

Tel: (517) 507-5067

Fax: (866) 461-4103

Email: rickjames@e-coustic.com